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ABSTRACT

A study was conducted to determine the relationship between motor and verbal ability traits, instructional treatments, and test instruments. Two programed instruments were developed to teach art concepts to sixth grade students. One instrument, termed manipulative, used a programed text with objects and artifacts that the students handled during instruction. The other instrument, termed non-manipulative, used a programed text with pictures of objects and artifacts used in the manipulative instrument. Two tests were developed to measure learning achievement. One test was a series of "fill-in-the-blank" questions; the other test required the students to use clay to demonstrate their understanding of the art concepts. When these instruments were used with 112 out of 516 students who had been identified as having either high-verbal-low-motor or low-verbal-high-motor ability traits, it was found that there was no significant correlation between short-term learning and instructional treatment. However, significant correlations were found between retention and instructional treatment and between testing methods and ability traits. One practical classroom application of the results is that it is important for the means of demonstrating learning (testing) to be related to the individual student's ability traits. (JY)

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AN EXPERIMENTAL STUDY TO EXAMINE THE RESPONSES OF SIXTH GRADE STUDENTS TO PROGRAMMED ART INSTRUCTION AND EVALUATIVE INSTRUMENTS DESIGNED TO CORRESPOND TO SELECTED ABILITY TRAIT VARIABLES

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December, 1970

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Damascus Elementary School, Damascus, Virginia
William King Elementary School, Abingdon, Virginia
High Point Elementary School, Bristol, Virginia
Duncan Elementary School, Duncan, South Carolina
Startown Elementary School, Newton, North Carolina
Parkway Elementary School, Boone, North Carolina
Shouns Elementary School, Mountain City, Tennessee
Neva Elementary School, Mountain City, Tennessee
Laurel Bloomery Elementary School, Laurel Bloomery, Tennessee

Appreciation is also expressed to the C.H. Stoelting Company for permission to reproduce tests which appear in the Appendix.

Summary of the Study

The purpose of this study was to determine the effects of two kinds of instructional instruments and two kinds of testing instruments on the learning achievement of sixth grade subjects identified as having special ability traits. It was hypothesized that (1) students' motor or verbal ability traits will be more highly related to learning achievement when they receive instructional treatment which is designed to correspond to their ability traits, (2) students' motor or verbal ability traits will be more highly related to learning achievement when they are tested through instruments designed to correspond to their ability traits, (3) students' motor or verbal ability traits will be more highly related to learning achievement when they receive both instructional treatment and testing through instruments designed to correspond to their ability traits, and (4) students' learning achievement will be greater, regardless of ability traits, when both treatment and tests are designed to correspond to the same ability trait.

Procedure

Two programmed instruments were used to teach four art concepts. These were aspects of positive and negative volume in sculpture termed solid, void, concave and convex. One instrument, termed Manipulative, used a programmed text with objects and artifacts which the subject handled during instruction. The other instrument, termed Non-manipulative, used a programmed text with pictures of the objects and artifacts used in the Manipulative instrument. Two tests were used to measure learning achievement. The first, termed Pencil-and-Paper Achievement Test involved "fill the blank" sentences, and the second, termed Clay Object Achievement Test, required the subject to demonstrate learning in a novel and manipulative manner.

Five hundred and seventeen sixth grade students from nine elementary schools in Virginia, Tennessee, North Carolina, and South Carolina were given motor and verbal ability tests. Verbal ability was measured through the SRA Primary Mental Abilities Tests, and motor ability was measured through selected portions of the Lincoln-Oseretsky tests. Subjects were divided according to sex and ability traits of high motor-low verbal or low motor-high verbal. Only subjects with extreme differences in these ability scores were selected. Division into sixteen groups of seven each according to sex, ability trait, treatment, and test was accomplished through random numbers. Testing of subjects was made prior to treatment; all students scored zero on the tests for prior knowledge. Treatment was administered, with achievement tests being given immediately following and again, for long-term retention testing, after a twenty-eight day interval.

Analyses of data were made through (a) analysis of variance for the entire group of subjects to examine main effects of sex, ability, treatment, and test interaction and to determine acceptance or rejection of the hypotheses, and (b) analyses of variance for each of the sixteen experimental groups to identify more specifically the effects of treatment and tests.

Results

It was found that manipulative or non-manipulative programmed instruction did not result in significant differences in learning achievement in relationship to motor or verbal abilities when subjects were tested immediately after the learning experiences. However, the interaction of ability trait and instructional treatment designed to correspond to the ability trait was significant for retention testing. Tests which were designed to relate to the special ability traits did result in significant differences in the indication of learning achievement for both short-term and long-term retention. It was not found, however, that the reception of both treatment and test instruments designed to correspond to the subject's ability traits were necessary to achieve significant differences in learning. As a result of these findings it would appear that it is advantageous for the instrument to be related to the special ability trait of the individual, but that it is significantly more important that his means of conveying the learning he has achieved be related to his abilities.

This might be interpreted in terms of practical classroom application to indicate that the same instructional means may be used for groups containing children with varied levels of motor and verbal abilities, but that provision should be made, in determining the achievement of learning objectives, for each child to express this achievement through means related to his special ability traits.

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CHAPTER I

BACKGROUND FOR THE STUDY

The questions of how children differ in their means of learning and in the rate, extent, manner, and depth in which this learning occurs has concerned educators and psychologists for many years. Although numerous investigations have been undertaken, these have not as yet resulted in a unified body of knowledge concerning the nature of individual differences in learning. A general acceptance that such differences do exist has led to the application of intuitive approaches to the meeting of individual learner needs. There are strong indications, however, that individual needs are not being met through these procedures and that research should be undertaken to identify both differences in learners and instructional instruments best suited to individual needs.

Some of the most pressing problems in elementary education currently are those involving increased population in the schools, acceleration of learning in many subject areas, increased number of subject areas to be studied in each grade level, and the recognized need for individual attention to each child. Various solutions are being tried with varied results. One direction in which a partial solution may be found is in the use of computer-assisted instruction in which programs may be tailored to meet the specific ability trait needs of each kind of student.

This study is based primarily upon the findings of a smaller effort in Florida in which 135 sixth grade students in one school were tested for specific ability trait variables, given instructional instruments designed to correspond to these variables, and finally given achievement tests which were designed to correspond to the same variables. The indications from the study were that students with extreme ability trait scores tend to perform significantly better when both treatment and test correspond to their special abilities. The expansion of this study, along with some refinement and alteration of the instruments and design of the research, was made in order to learn whether or not this finding might be related to a larger and more widely spread population.

Individual Differences

Ability traits as a basic factor in man have not been generally included in intelligence measures used normally as predictors of performance in learning. There is a need for identification and classification of these traits in terms of learner use as mediators during learning experiences and subsequent modification of educational practices to include attention to these individual differences in children.

The pervasive use of intelligence tests to establish levels of learning ability and the acceptance of these levels as predictive measures of performance for all children is an indication of the widespread inattention given by psychologists to individual differences. A reliance upon predictions based on a generality of behavioral laws is in conflict, however, with man's habits of selective mating. Travers (1967) explains the unsuitability of man as a laboratory strain because of his selective

mating practices. These have resulted in the development of a species with large individual differences within the nervous system. The members inherit these differences which are then further compounded by differences in environmental conditions during the child-rearing stages. These individual differences in the nervous system can be described as initial states which exhibit some stability and generality. This stability has been established through cross-sectional studies as not likely to change unless the individual is subjected to marked enviornmental changes.

Ability traits are described by Cronbach (1967) as an aptitude or a complex of characteristics that interact with a particular educational treatment to account for an individual's end state. These characteristics then determine what he learns, how much he learns, or how rapidly he learns. Carroll (1967) defines an aptitude as the possession in part of "prerequisite knowledges and skills," or, conversely, the lack thereof.

Cronbach (1969) further defines abilities through the statement that the score on a task serves to indicate that the individual possesses or does not possess, in conjunction, all of the abilities required to successfully perform it. Fleishman (1967) describes abilities as score consistencies between separate performance measurements. These score consistencies are brought by the learner to any new task he encounters. These may be legitimately considered as "descriptive parameters in the learning process." Thus, if it is accepted that traits do exist in man, then abilities may be assumed to have the position of constructs within any tasks learning situation. Such a construct is measurable and serves as a mediating factor which tends to result in similar responses by Ss to differing stimuli.

Ability Traits and Learning

Individual differences have been neglected by psychologists in an optimistic reliance upon the generality of behavioral laws. Intelligence can be defined as ability to learn; however, Stake (1961) cautions that there is danger in relying solely on intelligence tests. The controversy about whether a single factor or a group of factors involved in intelligence is of particular significance in relationship to the concept of differing ability traits. Fleishman (1967) identifies intelligence as a combination of certain basic abilities which are called upon by the individual to contribute toward achievement in a variety of activities. Woodrow (1946) found that rate of learning is entirely inconsistent within varying tasks, and that there is, therefore, no justification for the use of mental test scores as learning predictors. On the other hand, Ferguson (1956) views ability traits as useful in making predictions about subsequent learning performance in relationship to tasks involving differential transfer.

In approaching a learning experience the individual tends to rely consistently upon those ability traits which have been habitually used. Kagan (1964) describes these as factors which control the specific learning processes of the individual and which become preferences for specific modes of organization and categorization within the learning process. Performance is theorized by Hull (1943) to be a function not only of habit strength but of other constructs which may be affected by individual differences, such as drives and inhibitions.

Gagne (1962) identifies aptitude test scores with entering behavior, meaning behavior that is particularly relevant during the initial stages of learning and that is decreasingly relevant thereafter. Certainly a student may be expected to efficiently learn tasks that call upon his special abilities and to perform poorly on those that emphasize ability factors which he does not consistently rely upon. A study of subject-matter content variables as related to human aptitudes by King (1967) resulted in the conclusion that "achievement of students can be enhanced by assigning them to instructional materials known to be optimally related to their ability patterns. Testing instruments were included by Force (1968) in an examination of the interaction of learning and achievement instruments designed to correspond with individual ability traits. It was found that only when the testing means also related to ability traits were significant differences apparent in achievement through ability trait related instruments. If tests are not designed to match ability traits, final scores are measured through and dependent upon a different pattern of abilities.

Habitual dependence upon ability traits appears to alter the traits themselves. Thorndike (1925) stated that equalizing practices increase differences. Therefore the practice of presenting an entire class with the same ability-factor content in learning material would tend to increase differences in ability traits. Thus an examination of the relative desirability of decreasing or increasing differences in children might be essential.

Ability Traits as Mediators

Increasingly, attention has been given to factors specific to learning tasks. However, it seems possible to identify more general ability traits which can be said to enter into the performance of individuals in learning experiences. The identification of an individual difference variable is not a simple task and the development of reliable measures of ability traits requires systematic and arduous work. Jenkins (1967) urges the development of a taxonomy of individual difference variables which are traits within the individual having some stability and generality.

Duncan (1961) describes the need to study individual differences through both task-factor and treatment-trait interactions in which the individual ability trait variables have been identified in experimental subjects through tests prior to the experience of the problem. Much of the research concerning problem-solving has dealt with ability traits as "mediators" between stimuli and response and these have primarily dealt with traits such as rigidity, availability of function, cognitive style, and strategy.

An interaction between ability measures and a training instrument is to be commonly expected. Correlations of achievement with ability traits can identify those students who will achieve most or least from similar training instruments. The clarification of functional relationships occurring during such experimental conditions should serve to help define the ability trait processes relied upon by the Ss. The goals of prediction and behavioral controls are basic to the behavioral sciences according to Roberts (1969). He identifies the primary objectives of

learning experiments as being toward the development of reliable predictions of the effect of varied treatments on groups rather than in relationship to specific individuals.

Averaging of Differences

When groups of Ss are given experimental treatments, differences are often attributed to the treatment variable under investigation. This implies that the treatment variable is responded to by all Ss equally and avoids confrontation with differences within the Ss. Jensen (1967) warns that the questions we ask often are answered inadequately through statistical comparisons between group means.

This raises the question of the degree of difference in alternative ability traits required before the Ss will indicate a clear preference for one treatment over another. Force (1968) found that an analysis of variance, in which the achievement scores of the total number of Ss were used without selection of extreme differences in ability traits, did not indicate significant interaction between ability trait and treatment. However, an analysis of such interaction when extreme ability groups were examined indicated highly significant interactions. This might imply that only those students with such extreme differences tend to rely upon processes relating to specific abilities.

Ability Traits and Art Education

Perhaps one of the most significant areas in which attention should be given to individual differences is in the art experiences provided for children. In an age in which concern about the quality of living is intensified, we have included as a foremost function of art education individual aesthetic and perceptual development. However, before this goal can be achieved effort must be made to solve some of the difficulties built-in to our present systems of education. The educational tactics used in most classrooms are intended to minimize the problems involved in attending to individual ability trait differences. The problems of dealing with crowded classrooms, a wide range of subject demands, and acceleration demands in many subject areas have made concern with individual differences very complicated. In many cases, the cost of differentiating instruction is prohibitive in terms of teacher time and equipment.

The problems are multiplied when joined with the unique difficulties encountered in an art program. First, it is unlikely that we will ever be able to provide the number of art specialists who would be needed to interact with all children, it is unrealistic to believe that we are now, or can in the near future, prepare elementary teachers to deal with art in the terms needed to meet the goals. In view of the population growth it is not probable that we can reduce class sizes to groups amenable to individual art instruction. The seriousness of this problem in all areas, not art alone, makes it imperative that researchers in education, who have advocated attention to individual differences, become involved in studies related to identifying possible solutions.

Justification for Ability Trait Study

It is the task of the psychologist to devise or select treatments that interact with ability traits in individual students. The goals of education are for each child, not merely for those who can bring certain selected abilities to the tasks presented. Matching instructional method to individual ability variables demands the efforts of experimental psychologists and educators alike.

In establishing an argument for the theses of this study, the following recommendations are cited:

> Ferguson (1954) urged that learning theories incorporate attention to individual abilities. He urged that less concern be paid to culture-fair tests which may neglect and obscure ability traits instead of identifying those strategies which interact between learner and task.
>
> Glaser (1967) recommends that we become more active in postulating initial properties of the learner in terms of interaction with learning.
>
> Jensen (1962) called for a learning theory which would take into consideration instruction designed to suit the individual abilities of pupils.
>
> Cronbach (1967) advised research designed to take a differential variable held promising and the design of alternative treatments to interact with that variable.
>
> Melton (1967) states that the experimentalist can look at individual differences as a means of adding information to the description of constructs.

Statement of the Problem

Two problem areas are involved in the investigations of this study. The first concerns whether or not programmed instruction, when devised in terms of some special ability-trait of the student, would result in an increase in learning achievement of an art concept. The basis for this is discussed in the background for the study and is founded on tentative establishment by differential psychologists through research that learning material which is related to abilities of a student tend to increase his achievement. From this the assumptions were derived that (a) achievement in learning an art concept can be the result of the interaction of the instructional media and the learner's ability, and that (b) it is possible that media can be designed to correspond to ability-traits of students in order to increase learning.

The second area investigated involves testing with an instrument which is also designed to relate to the student's special abilities. This occurs in the study through a novel test situation using means other than

the familiar paper-and-pencil type. If a student learns through instructional instruments which relate to his ability, then perhaps he can express this learning best through testing instruments which have also been designed to relate to his abilities. The assumption resulting from this second problem area was that (c) the learning achievement of a student taught through an instrument designed to relate to his abilities can be measured through a novel test when that test has also been designed to relate to his special abilities.

Hypotheses

H_1: Students' motor or verbal ability traits will be more highly related to learning achievement when they receive instructional treatment which is designed to correspond to their ability traits.

H_2: Students' motor or verbal ability traits will be more highly related to learning achievement when they are tested through instruments designed to correspond to their ability traits.

H_3: Students' motor or verbal ability traits will be more highly related to learning achievement when they receive both instructional treatment and testing through instruments designed to correspond to their ability traits.

H_4: Students' learning achievement will be greater, regardless of ability traits, when both treatment and tests are designed to correspond to the same ability trait.

Limitations of the Study

1. The population was limited to five hundred seventeen sixth grade students from Tennessee, Virginia, South Carolina, and North Carolina.

2. The concepts presented in the programmed instruments were limited to four aspects of positive and negative volume in sculpture occurring in volume of matter.

3. Motor ability evaluations as measured by the Lincoln-Oseretsky Test portions were primarily those involving fine motor abilities such as eye-hand coordination and finger dexterity.

Definitions

For the purpose of this study the terms used were defined as follows:

Ability-trait--Ferguson (1954) defines ability as the "performance of an individual under specific situations." An ability-trait was accepted to indicate the habitual performance responses under such specific situations.

Concave--Refers to an area in which space appears to push into a solid mass, creating a contour which moves inward.

Convex--This refers to an area in which solid mass appears to push into space, creating a contour which moves outward.

Positive and negative--Positive refers to those areas of volume which fill space with solid or convex mass and negative refers to those areas of volume constituted by space wholly or partially surrounded by mass forming void or concave areas.

Solid--This refers to a clearly defined mass having measurable weight and being tangible in three dimensions.

Space--Any area established and defined by the objects which occupy it, and any area which pushes into mass in order to form negative areas or into which mass protrudes in order to form positive areas.

Void--Any hole or opening perceived visually through limiting walls.

Volume--This signifies defined regions of space or defined regions of solid mass.

CHAPTER II

METHODS AND PROCEDURES

Subjects

Subjects used for the study were selected from among sixth grade students in nine Tennessee, Virginia, South Carolina and North Carolina elementary Schools. These schools were selected at random from lists of elementary schools contained within the region and within a single day's drive from Appalachian State University. Five hundred and seventeen students were given verbal and motor ability tests. One hundred and twelve of the population were selected to be used as experimental groups in the study. Selection of the subjects was made through (1) division according to sex, (2) elimination of all students having less than a thirty point difference between standardized motor and verbal ability scores given percentile ranks, and (3) random selection to provide groups of equal size in each of sixteen experimental groups.

Testing of Subjects for Ability Traits

The Science Research Associates' Primary Mental Abilities Test of Verbal-meaning developed by Thurstone and Thurstone (1958) and selected portions of the Lincoln-Oseretsky Motor Tests adapted by Sloan (1959) were used to identify motor and verbal ability traits. Those portions of the Lincoln-Oseretsky Test which were used for this study are shown in Appendix A. The 517 students were given the Verbal-meaning, Reasoning, and Space sections of Form AH of the SRA Tests. Although the Verbal section was the only test used for evaluation purposes of this study, the other two were given in order to identify variables which might influence learning achievement of individuals. A correlation of these abilities and the motor ability scores is shown in Appendix A. Percentile ranks of standardized verbal test scores for females and males separately were figured in relationship to the entire population of each sex.

The seven items used from the Lincoln-Oseretsky Test were those used by Force (1968) to identify fine motor abilities. Standardized scores from the Motor Ability Tests were translated into female or male percentile rank scores in relationship to the entire population as was done with the Verbal-meaning test scores.

Division of Subjects into Groups

Initial division into groups was made based on sex, since Thurstone (1958) found that sixth grade students' verbal ability norms varied according to sex and Sloan (1954) found that motor ability norms also varied according to sex. In addition, in the study by Force (1968) it was found that treatment, test, and ability trait interaction differed significantly according to sex.

Selection of students having at least a thirty point difference between their motor and verbal ability percentile rank scores also resulted from the study by Force. Students having more nearly balanced levels of motor and verbal abilities were found to be relatively unaffected by

differences in treatment and tests. It was found that differences did not predict preferences on a proportional scale; therefore the use of widely differing abilities avoided the averaging out of differences warned against by Jensen (1962).

Table 1 indicates the initial division of students according to sex and extreme ability groups.

Table 1. Division of subjects according to sex and extreme ability trait scores on verbal and motor tests

Sex	Ability Traits	Number of Subjects
Female	High Verbal, Low Motor	28
	Low Verbal, High Motor	28
Male	High Verbal, Low Motor	28
	Low Verbal, High Motor	28
	Total Number of Subjects	112

Of the 517 students tested, 281 were males and 236 were females. Scores indicating motor abilities greater than verbal abilities were made by 56% of the males and 39% of the females. The reverse trend, verbal abilities higher than motor, occurred for 44% of the males and 61% of the females. The percentages for each of these divisions were consistent with the percentages scoring one ability trait higher than the other as is shown in Figure 1. However, the actual numbers of students available for each experimental group varied considerably. A 30 point difference was chosen arbitrarily as being the probable largest difference that could be attained and still retain not less than 7Ss in each experimental group. After the establishment of the 30 point level for acceptance, it was found that 90 males (32% of population) and 36 females (15% of population) were available in the motor ability greater than verbal ability groups. The verbal ability greater than motor ability groups numbered 48 males (17% of population) and 75 females (31% of population). These are indicated in Figure 1.

Instruments Used in the Study

The four instruments devised for and used in the study by Force (1968) were used with minor changes and refinements. These changes were primarily in the area of wording of statements by the administrator. Two of the instruments were programmed instructional treatments dealing with an art concept and two were achievement tests to be used immediately after treatment and as retention tests.

Programmed Treatment Instruments

The two programmed instruments were designed to teach four cognitive concepts dealing with aspects of positive and negative volume in sculpture

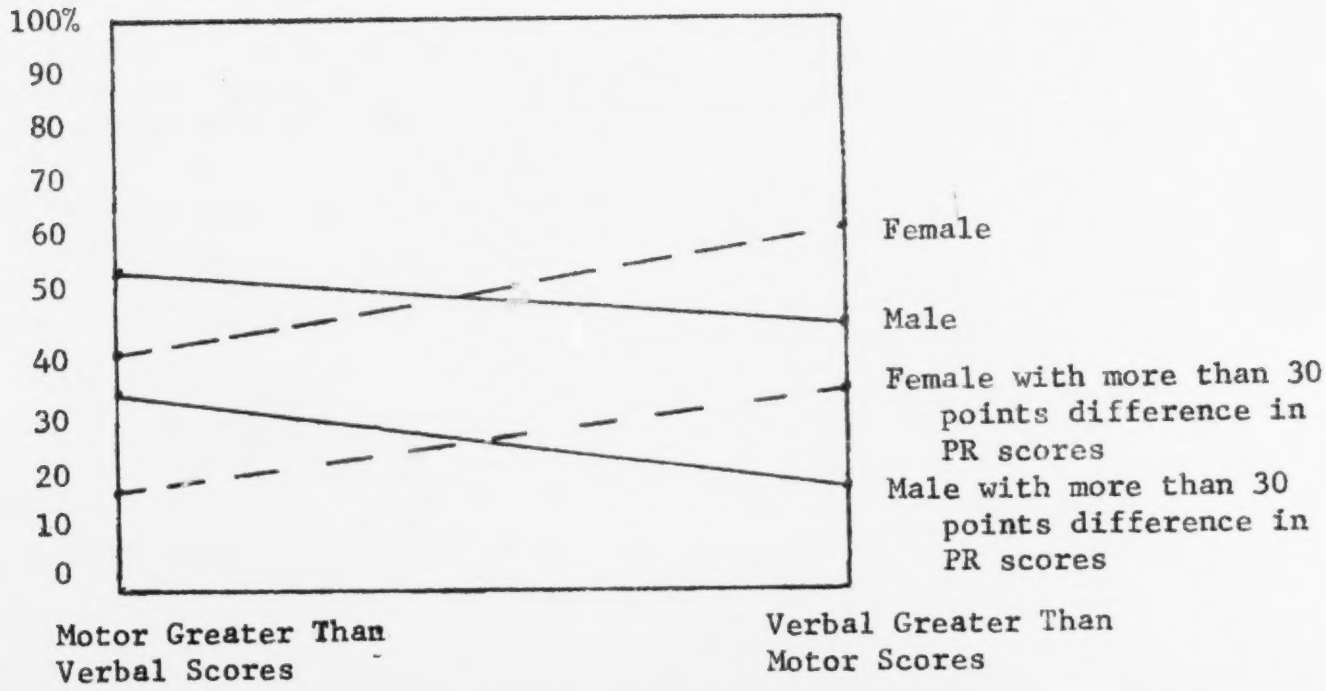

Figure 1. Percentages of male and female students with motor greater than verbal or verbal greater than motor ability scores and the percentages of male and female subjects with more than a 30 point difference between motor and verbal ability percentile rank (PR) scores.

(see Appendix B). These aspects are instances of solid, void, concave, and convex volume. They were chosen because they appear to have less ambiguity of definition and to be easier to deal with in quantitative measurement than others. They were also found to have been totally without the realm of prior experience for the sixth grade students in the earlier study; therefore it was felt that previous conscious involvement with them prior to treatment was improbable for these students.

The instruments are termed Manipulative and Non-manipulative. The Manipulative Instrument involved programmed material including (a) written instruction in book form, (b) artifacts to be manipulated manually, and (c) sculpture. The Non-manipulative Instrument used (a) written instruction in book form and (b) pictures of artifacts and sculpture. Copies of these Instruments are to be found in Appendix B. Motor factors in the learning material were minimized in the Non-manipulative Instrument and verbal factors were minimized in the Manipulative Instrument.

Both instruments were directed toward the sixth grade student, covered the same material, progressed through equivalent steps and information, and provided instruction relating only toward the understanding of these four concepts. Both instruments contain programmed instruction, the Manipulative instrument having three-dimensional objects, and the Non-manipulative instrument having pictures of objects.

The branching style of programming was used in order to offer the subject the greatest amount of individual reactions in the learning process. Procedure was from the known to the unknown and from the simple to the more complex. Effort was made to eliminate differences caused by prior knowledge through the programmed explanation of all terminology with which the child might not already be familiar. The term sculpture, for example, was found to be unknown by some students in the preliminary Florida study and was added to the programmed material during that effort.

Art Learning Achievement Tests

One of the two achievement tests devised for the study by Force (1968) was given to each subject according to his assigned category in the research design. These two tests were used to measure short term (Post Test 1) and long-term (Post Test 2) retention. The first test consisted of eight "fill the blank" sentences which required the subject to recall and write in the correct terms identifying the four kinds of positive and negative volume which had been described in the learning instruments. This was a paper-and-pencil test referred to as P.P.A.T. in the remainder of this study. A complete copy of the P.P.A.T. is to be found in Appendix C.

The second achievement test was used to provide a manipulative demonstration of the subject's knowledge of the concepts. The student was given one-half pound of clay and asked to use it to demonstrate his knowledge of the four concepts. This is termed a "clay object achievement test" and is referred to as C.O.A.T. in the balance of this study. Instructions and description of the test are in Appendix C.

Assignment of Subjects to Treatment-Test Combinations

The initial design of the proposed study included control groups to be given pre, post, and retention tests without treatment in order to measure the effect of test repetition. However, a closer scrutiny of both the population and the study design indicated that such a group could be eliminated to advantage. It made possible the selection of groups with a wider difference between precentile rank scores on ability traits and therefore a clearer definition of the effects of these differences. In addition there appeared to be no import to any test repetition changes in achievement, since all subjects being compared were to receive the same repetitions. Permission was given by the H.E.W. Office of Education, Bureau of Research, to make this adjustment.

After initial division of subjects into groups, according to ability and sex, random numbers were used to further divide them into sixteen groups of seven each, for assignment to varied treatment-test combinations. This division is shown in Table 2.

Means and Standard Deviations were examined for motor ability and verbal ability for each of the experimental groups. These are shown in Table 3 for female subjects and Table 4 for male subjects. In Table 3 it will be noted that the difference between motor ability means for the high verbal females was .7 or less; the difference between verbal ability means was 1.6 or less. Differences in motor ability means for females with high motor and low verbal scores was .4 or less, and in verbal ability, the difference in means was 1.9. It should be noted that, while the verbal and motor means for the "low" ability traits are quite similar, the "high" abilities means do differ up to 5.6 points. Male ability score means are shown in Table 4. The difference between motor ability means for the high verbal males was .5 or less and between verbal ability means was 1.7 or less. As was found in the female scores, the low ability trait scores were relatively similar while the high ability traits differed by as much as 4.7 with the higher scores appearing in the high verbal groups.

Table 2. Division of 112 subjects into ability-trait groups according to treatment and tests to be administered to each group.

Female	Ability Traits	Treatments	Tests
7	High Motor, Low Verbal	Manipulative	P.P.A.T.
7	High Motor, Low Verbal	Manipulative	C.O.A.T.
7	High Motor, Low Verbal	Non-manipulative	P.P.A.T.
7	High Motor, Low Verbal	Non-manipulative	C.O.A.T.
7	Low Motor, High Verbal	Manipulative	P.P.A.T.
7	Low Motor, High Verbal	Manipulative	C.O.A.T.
7	Low Motor, High Verbal	Non-manipulative	P.P.A.T.
7	Low Motor, High Verbal	Non-manipulative	C.O.A.T.
Male			
7	High Motor, Low Verbal	Manipulative	P.P.A.T.
7	High Motor, Low Verbal	Manipulative	C.O.A.T.
7	High Motor, Low Verbal	Non-manipulative	P.P.A.T.
7	High Motor, Low Verbal	Non-manipulative	C.O.A.T.
7	Low Motor, High Verbal	Manipulative	P.P.A.T.
7	Low Motor, High Verbal	Manipulative	C.O.A.T.
7	Low Motor, High Verbal	Non-manipulative	P.P.A.T.
7	Low Motor, High Verbal	Non-manipulative	C.O.A.T.

112 Total number of subjects

Table 3. Means and standard deviations of 56 female subjects with high verbal and low motor or low verbal and high motor scores according to treatment and test to which they were assigned.

No.	Ability	Treatment/Test	MA Mean	S.D.	VA Mean	S.D.
7	High Verbal Low Motor	Manipulative P.P.A.T.	5.4	1.5	14.3	3.8
7	High Verbal Low Motor	Manipulative C.O.A.T.	5.1	2.0	13.0	3.7
7	High Verbal Low Motor	Non-manipulative P.P.A.T.	4.7	1.3	15.0	3.5
7	High Verbal Low Motor	Non-manipulative C.O.A.T.	5.4	1.4	15.6	3.1
7	Low Verbal High Motor	Manipulative P.P.A.T.	10.0	3.4	5.7	2.6
7	Low Verbal High Motor	Manipulative C.O.A.T.	10.4	2.1	5.6	2.8
7	Low Verbal High Motor	Non-manipulative P.P.A.T.	10.1	2.5	4.7	2.9
7	Low Verbal High Motor	Non-Manipulative C.O.A.T.	10.0	2.6	6.6	1.1

N=56

Table 4. Means and standard deviations of 56 male subjects with high verbal and low motor or low verbal and high motor ability scores according to treatment and test to which they were assigned.

No.	Ability	Treatment/Test	MA Mean	S.D.	VA Mean	S.D.
7	High Verbal Low Motor	Manipulative P.P.A.T.	6.1	0.9	14.9	3.2
7	High Verbal Low Motor	Manipulative C.O.A.T.	5.9	0.9	13.3	1.7
7	High Verbal Low Motor	Non-manipulative P.P.A.T.	5.6	1.4	15.0	3.4
7	High Verbal Low Motor	Non-manipulative C.O.A.T.	5.9	1.3	14.7	2.8
7	Low Verbal High Motor	Manipulative P.P.A.T.	10.6	2.3	7.1	2.3
7	Low Verbal High Motor	Manipulative C.O.A.T.	10.3	1.3	6.9	2.0
7	Low Verbal High Motor	Non-manipulative P.P.A.T.	10.3	1.6	7.3	1.4
7	Low Verbal High Motor	Non-manipulative C.O.A.T.	10.6	2.0	7.1	2.0

N=56

Administration of Treatments and Tests

Each subject was given the treatments and tests individually and under conditions which permitted no communication with other subjects. Instructions to the subjects prior and during instrument administration are included with the instruments in Appendix C.

Achievement Tests C.O.A.T. or P.P.A.T. were given to each subject prior to administration of the treatment according to the experimental group to which the subject was assigned. This was done in order to establish whether or not any prior knowledge of the positive and negative concepts should be considered in the statistical evaluation. Since no subject scored on any portion of these tests, it was concluded that no prior knowledge of these concepts as presented existed. The appropriate test was also given immediately following the instructional instrument.

Retention Tests

Following a period of 28 days each subject was given the same test again in order to measure retention. Since the tests were designed not

to give indication of right, wrong, or preferred answers, it was felt that the greatest accuracy of data would be derived from their repetition. Since all individuals involved in the study had the experience of repeat testing, it was felt that the tendency of subjects to repeat prior answers need not interfere with evaluation.

Analysis of Data

Data were derived from scores by each subject on the test assigned to him on three occasions, (1) prior to administration of the instructional instrument, (2) immediately after the instrument, and (3) 28 days following the learning experience. The scores on these tests were examined in relationship to sex, extreme ability trait level, and treatment, in order to determine those combinations of sex-ability-treatment-test in which achievement might appear to be significantly better.

Methods of Analysis

An analysis of variance was done in order to examine main effects of treatment, achievement tests, and interactions of treatment and tests for male and female subjects having high motor-low verbal or low motor-high verbal abilities. This was done to determine the acceptance or rejection of the hypotheses of the study. Additional analyses of variance were done to examine the main effects of treatment and test interactions for each of the sixteen experimental groups. These were done to gain additional information, but were not used to determine acceptance or rejection of the hypotheses.

CHAPTER III

RESULTS AND DISCUSSION

The purpose of this Chapter is to present the results of the study and to discuss the meanings derived from the data. The results of each analysis performed were examined separately in terms of the hypotheses stated in Chapter I.

Hypothesis 1, that students' motor or verbal ability traits will be more highly related to learning achievement when they receive instructional treatment which is designed to correspond to their ability traits, was rejected for short-term retention tests and accepted for the long-term retention tests. Table 5 shows that Ability (B) and Treatment (C) have an interaction of well below the .05 probability level with an F ratio of 1.75 for the short-term test. Table 6, however, shows an interaction of B and C with an F ratio of 7.93 which is well above the 3.92 required for significance at the .05 level of probability.

Hypothesis 2, that students' motor or verbal ability traits will be more highly related to learning achievement when they are tested through instruments designed to correspond to their ability traits, was accepted for both the short-term retention tests and the long-term retention tests. The interactions of Ability (B) and Test (D) are shown in Table 5 for short-term tests and Table 6 for the long-term tests. B and D interaction reached the F ratio of 6.48 for the short-term tests and 6.61 for the long-term. Both of these are well above the .05 level of probability for significance.

Hypothesis 3, that students' motor or verbal ability traits will be more highly related to learning achievement when they receive both instructional treatment and testing through instruments designed to correspond to their ability traits, was rejected for both the short-term and the long-term tests. Tables 5 and 6 show an interaction F ratio of only .50 for for the short-term test and .37 for the long-term test.

Hypothesis 4, that students' learning achievement will be greater, regardless of ability traits, when both treatment and tests are designed to correspond to the same ability trait, was rejected for both the short-term and long-term tests. Table 5 shows an F ratio for Treatment (C) and Test (D) of 3.74 which approaches significance at the .05 level of probability, and Table 6 shows an interaction F ratio of 2.53, well below the required value of 3.92.

Table 5. Analyses of variance for subjects with extreme motor and verbal ability scores comparing major effects of sex, ability traits, and treatment in relationship to scores on short-term retention tests. *

Source	Sums of Squares	df	Mean Square	Effect	F Ratio	P
Mean	55.720	1	55.720	1.410	64.78	
Sex (A)	.223	1	.223	.089	.25	NS
Ability (B)	7.508	1	7.508	-.518	8.73	.05
Treatment (C)	.723	1	.723	.161	.84	NS
Test (D)	.080	1	.080	-.054	.09	NS
A x B	1.508	1	1.508	.232	1.75	NS
A x C	.080	1	.080	.054	.09	NS
A x D	2.008	1	2.008	.268	2.33	NS
B x C	1.508	1	1.508	.232	1.75	NS
B x D	5.580	1	5.580	.446	6.48	.05
C x D	3.223	1	3.223	.339	3.74	NS
A x B x C	1.080	1	1.080	.196	1.25	NS
A x B x D	.009	1	.009	-.018	.01	NS
A x C x D	.723	1	.723	.161	.84	NS
B x C x D	.438	1	.438	.125	.50	NS
A x B x C x D	.009	1	.009	.018	.01	NS
Error	82.57	96	.860			
Total	107.20	112				

* F value of 3.92 required for .05 level of significance

Table 6. Analyses of variance for subjects with extreme motor and verbal ability scores comparing major effects of sex, ability traits, and treatment in relationship to scores on long-term retention tests. *

Source	Sums of Squares	df	Mean Square	Effect	F Ratio	P
Mean	19.720	1	19.720	.839	33.13	
Sex (A)	.438	1	.438	.125	.73	NS
Ability (B)	1.508	1	1.508	-.232	2.53	NS
Treatment (C)	.009	1	.099	-.018	.01	NS
Test (D)	2.008	1	2.008	-.268	3.37	NS
A x B	1.080	1	1.080	.196	1.81	NS
A x C	.438	1	.438	.125	.73	NS
A x D	.223	1	.223	.089	.37	NS
B x C	4.723	1	4.723	.411	7.93	.05
B x D	3.937	1	3.937	.375	6.61	.05
C x D	1.508	1	1.508	.232	2.53	NS
A x B x C	2.008	1	2.008	.268	3.37	NS
A x B x D	.009	1	.009	.018	.01	NS
A x C x D	.009	1	.009	.018	.01	NS
B x C x D	.223	1	.223	.089	.37	NS
A x B x C x D	.009	1	.009	.018	.01	NS
Error	57.14	96	.595			
Total	75.27	112				

* F value of 3.92 required for .05 level of significance.

The Ability (B) and Test (D) interaction appears consistently as the strongest factor. Figures 2 and 3 show graphically this interaction for the short-term and long-term retention tests. In Figure 2 it is noted that immediately after the learning period the High Verbal subjects achieved greater learning when given the P.P.A.T. than when given the C.O.A.T., while the high motor ability subjects achievement was greater when they were given the C.O.A.T. than when they received the P.P.A.T. Figure 3 illustrates the changes in learning achievement after a four week period when the long-term C.O.A.T. and P.P.A.T. were administered. The loss of learning by the high verbal students given the P.P.A.T. was not as great as the loss of learning by the high motor student given the C.O.A.T. However, the greatest decrease in learning retention occurred for the high verbal subject who received the C.O.A.T. The high motor subjects did not tend to lose the learning achievement with time, when they had received the P.P.A.T., however, this achievement was exceptionally low for both the short-term and long-term tests.

The Ability (B) and Treatment (C) interaction becomes important in terms of retention. This is shown graphically in Figure 5. Although interaction is not significant during the short-term test, the long-term test was significant at the .05 level of probability. The high motor ability subject who was given the manipulative treatment achieved greater learning than when he received the non-manipulative treatment. The high verbal subject performed best when he was given the non-manipulative treatment rather than the manipulative treatment.

Table 5 indicates significance at the .05 level of probability for the ability factor (B) in terms of the short-term retention test with an F ratio of 8.73. This significance is lost after the four week time period, however, and resulted in a nonsignificant ratio of only 2.53, shown in Table 6.

The Effects columns in Tables 5 and 6 are used for two purposes. The first of these is to assist in determining the benefit of a certain factor or group of factors. For example, the effect -.518 for factor B in the short-term test analysis indicates that differences in factor B tend to decrease the test scores. High motor subjects had lower scores than high verbal and manipulative treatment subjects had higher scores than non-manipulative treatment subjects. It is important to note that the relative sizes of the effects agree with the relative mean squares and F ratio sizes.

The second use of the Effects columns is for predictive purposes. The purpose is to isolate the important effects and be able to control them in future experiments. The following examples are based on only significant or nearly significant factors and are actually terms in mathematical models. The calculated response is the predicted mean response for the particular variable combination.

Short-term Retention Test

$$Y_{ijkl} = 1/2(1.410 - .518\ X_2 + .446\ X_2X_4 + .339\ X_3X_4)$$

Long-term Retention Test

$$Y_{ijkl} = 1/2(.839 - .268\ X_4 + .411\ X_2X_3 + .375\ X_2X_4 + .268\ X_1X_2X_3)$$

Where $X_1 = \begin{cases} 1 & \text{Male (M)} \\ -1 & \text{Female (F)} \end{cases}$ $X_2 = \begin{cases} 1 & \text{High Motor (M)} \\ -1 & \text{High Verbal (V)} \end{cases}$

$X_3 = \begin{cases} 1 & \text{Manipulative (M)} \\ -1 & \text{Non-manipulative (N)} \end{cases}$ $X_4 = \begin{cases} 1 & \text{C.O.A.T. (M)} \\ -1 & \text{P.P.A.T. (N)} \end{cases}$

Example: $X_1 = 1$, $X_2 = 1$, $X_3 = 1$, $X_4 = 1$ or the group MMNM

Short term Retention Test

$Y_{MMNM} = 1/2(1.410 - .518 + .446 - .339) = .5$ predicted mean value for the MMNM subject group on short-term test.

Long-term Retention Test

$Y_{MMNM} = 1/2(.839 - .268 - .411 + .375 - .268) = .134$ predicted mean value for the MMNM subject group on the long-term test.

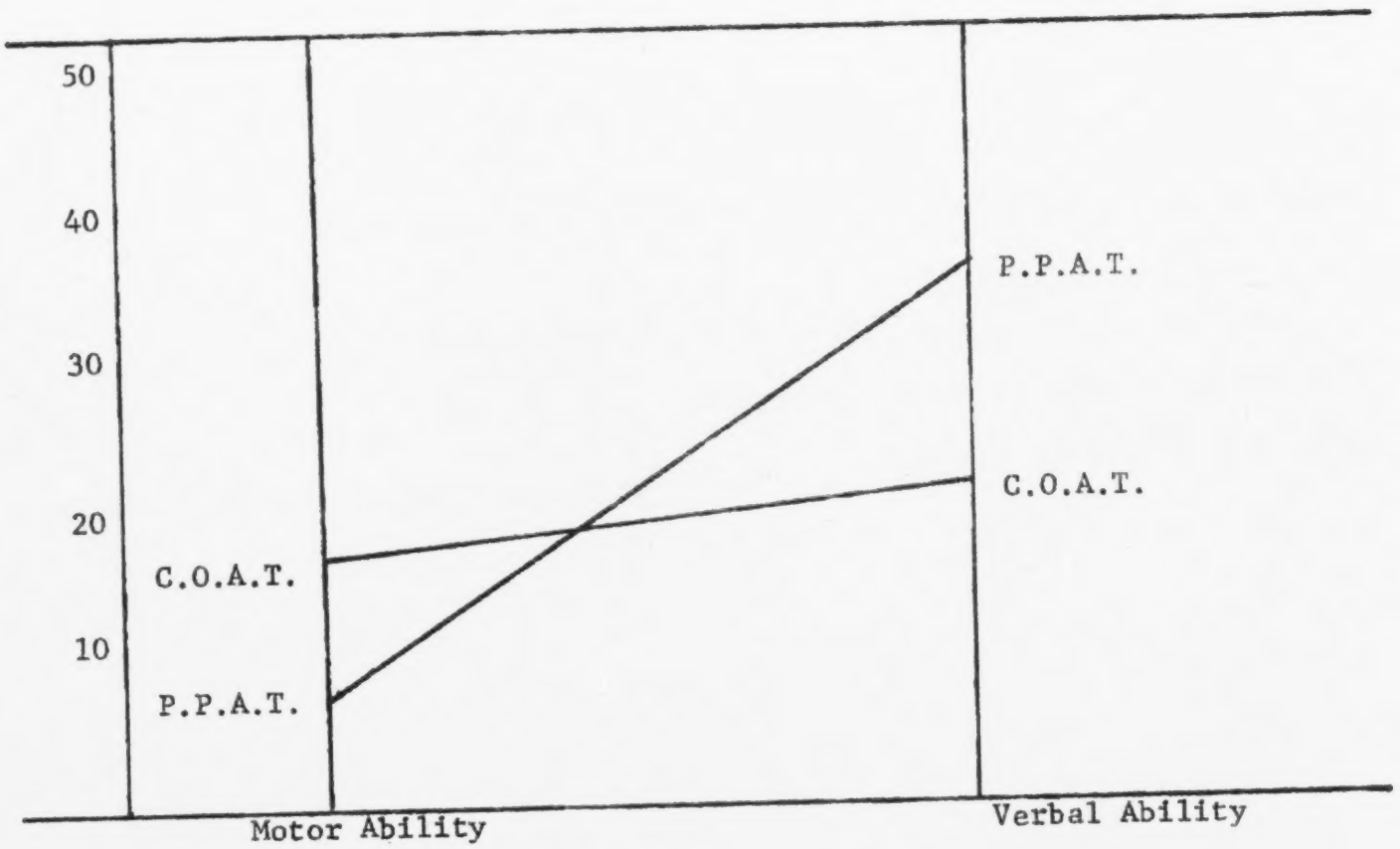

Figure 2. Graphs of ability trait (B) and Test (D) interactions for high motor-low verbal and low motor-high verbal subjects on the short-term retention tests. P.P.A.T. and C.O.A.T. using sums of scores.

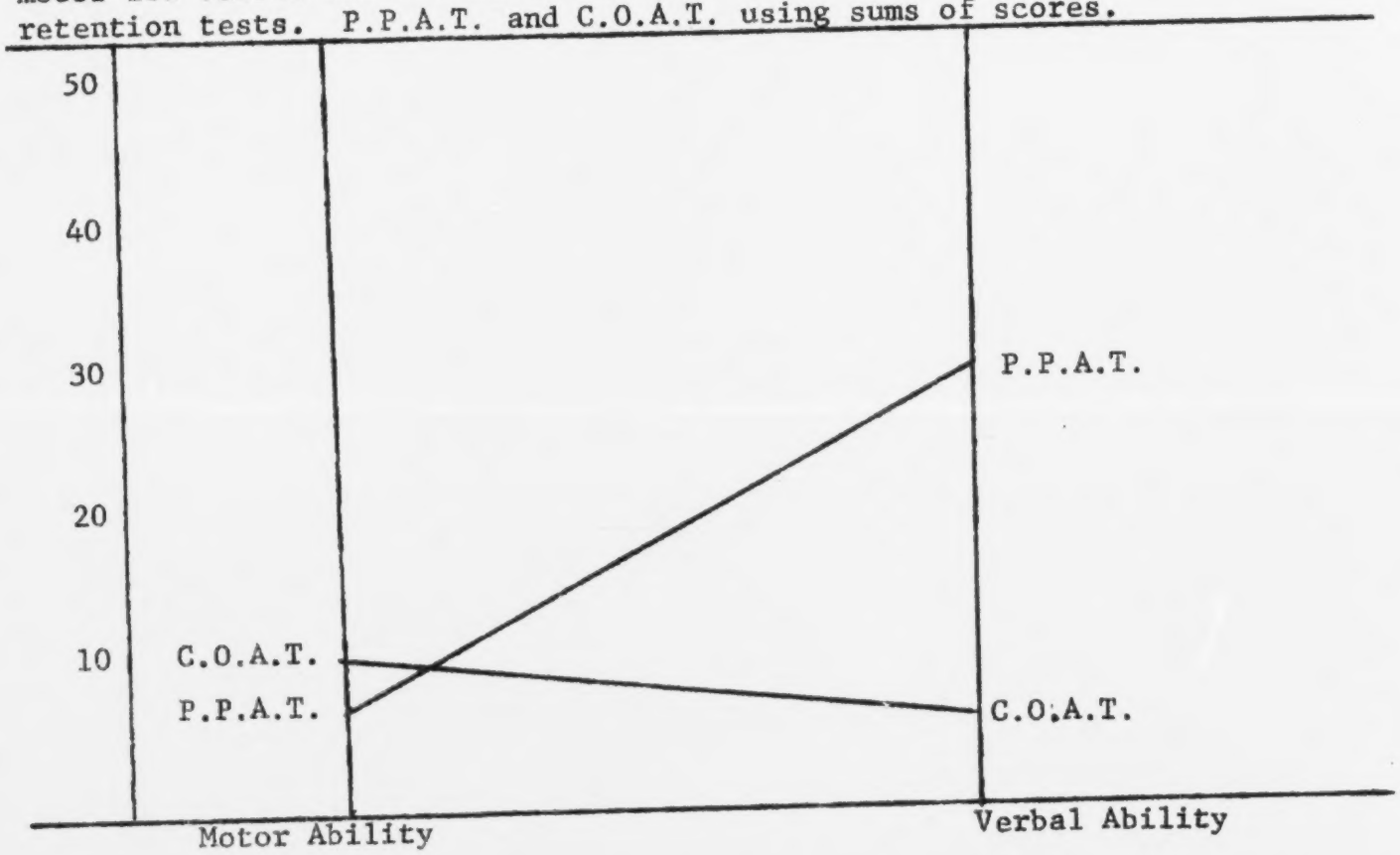

Figure 3. Graph of ability trait (B) and Test (D) interactions for high motor-low verbal and low motor-high verbal subjects on the long term retention tests P.P.A.T. and C.O.A.T. using sums of scores.

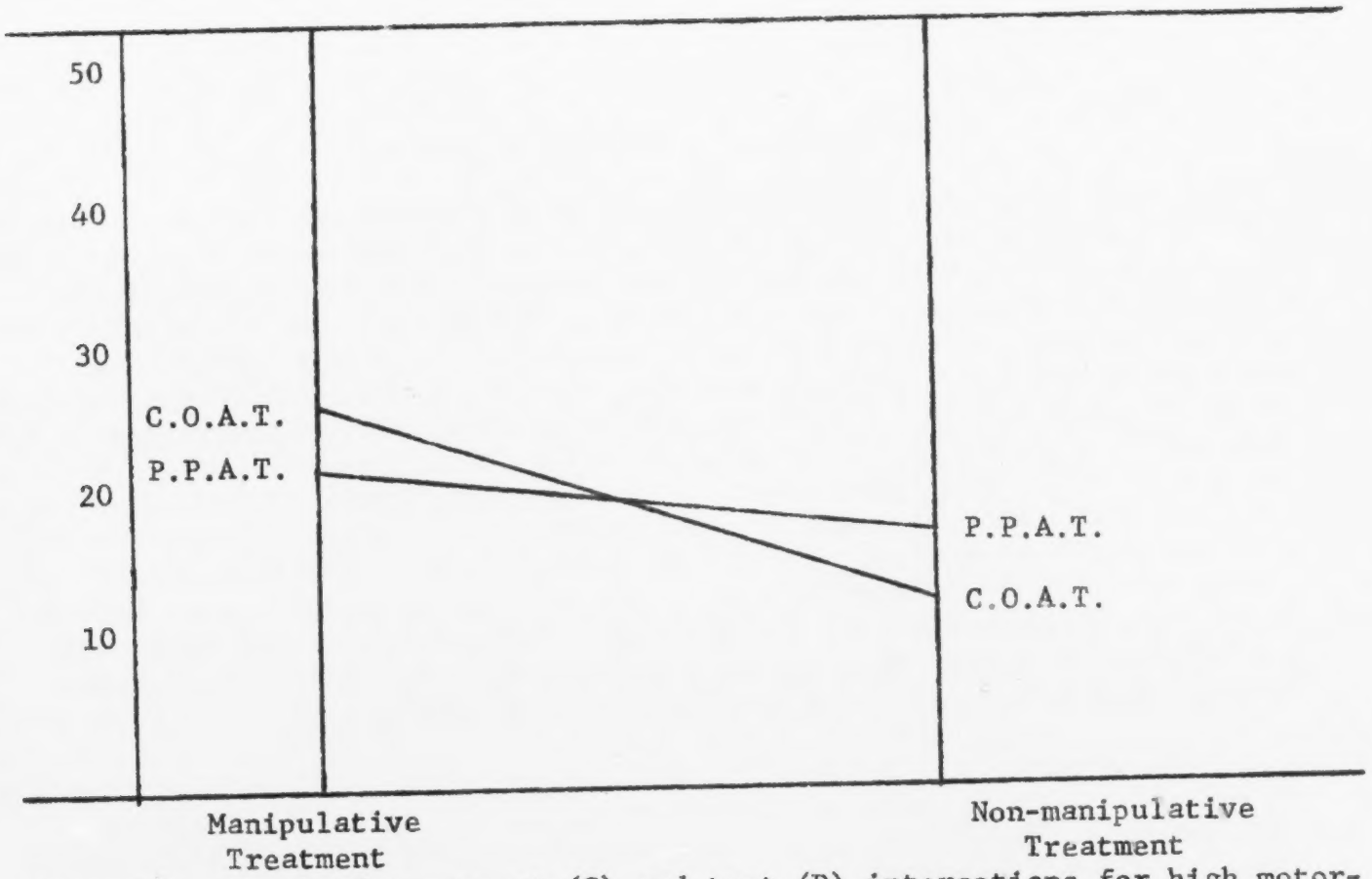

Figure 4. Graph of treatment (C) and test (D) interactions for high motor-low verbal and low motor-high verbal subjects on the short-term retention tests P.P.A.T. and C.O.A.T. using sums of scores.

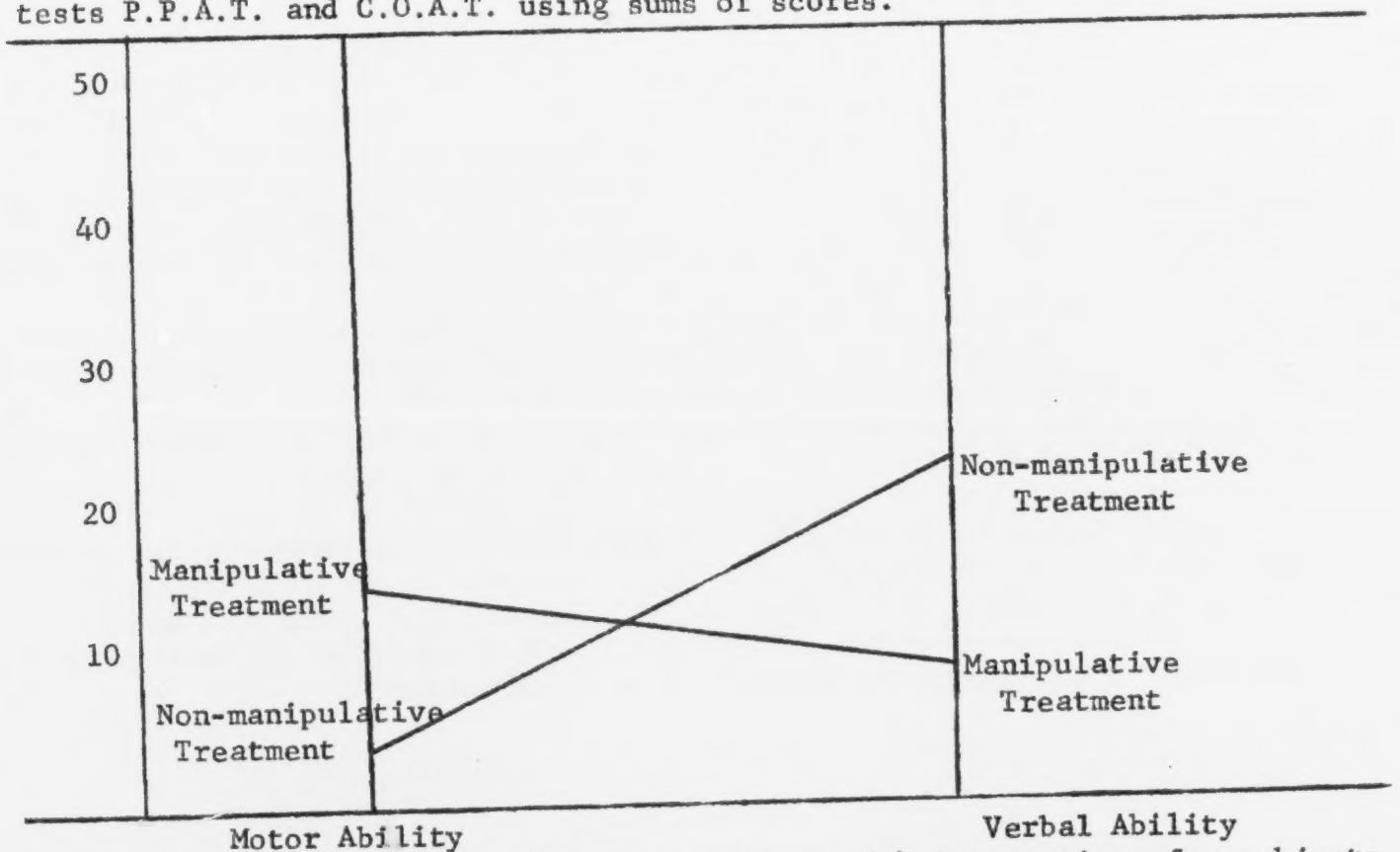

Figure 5. Graph of ability (B) and treatment (C) interactions for subjects with high motor-low verbal and low motor-high verbal abilities given manipulative or non-manipulative treatment for the long-term retention tests using sums of scores.

CHAPTER IV

Conclusions and Recommendations

It was found that manipulative or non-manipulative programmed instruction did not result in significant differences in learning achievement in relationship to motor or verbal abilities when subjects were tested immediately after the learning experiences. However, the interaction of ability trait and instructional treatment designed to correspond to the ability trait was significant for retention testing. Tests which were designed to relate to the special ability traits did result in significant differences in the indication of learning achievement for both short-term and long-term retention. It was not found, however, that the reception of both treatment and test instruments designed to correspond to the subject's ability traits were necessary to achieve significant differences in learning. As a result of these findings it would appear that it is advantageous for the instrument to be related to the special ability trait of the individual, but that it is significantly more important that his means of conveying the learning he has achieved be related to his abilities.

This might be interpreted in terms of practical classroom application to indicate that the same instructional means may be used for groups containing children with varied levels of motor and verbal abilities, but that provision should be made, in determining the achievement of learning objectives, for each child to express this achievement through means related to his special ability traits.

Test of ability traits should be devised and refined for greater accuracy of identification of these traits. Currently tests for ability traits tend to be lacking, not fully developed, or applicable only to special groups. Tests for those abilities which have been traditionally associated with learning achievement have already been highly refined, but tests to even minimally identify other special ability traits are rare.

Determination should be made of whether a student persistently uses a strategy or changes from one to another under varied situations. This might be accomplished through investigation of ability trait and treatment interaction for single subjects confronted with several treatment experiences and varied test situations dealing with differing concepts.

Research should be done to determine whether the usage of instructional media designed to correspond with ability-traits tends to increase the subject's dependency upon these traits. Should this occur, it would be necessary to examine the advantages and disadvantages of increasing individual differences in ability trait dependencies.

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APPENDICES

APPENDIX A

ABILITY TRAIT TESTS

TESTS SELECTED FOR USE FROM THE LINCOLN-

OSERETSKY MOTOR DEVELOPMENT SCALE

4. Touching Nose

Equipment. None.

Number of trials. One.

Directions. S is to stretch both arms out to the sides horizontally with index fingers extended and then touch his nose with each hand alternately three times. Eyes are kept closed and the head is kept still. E (examiner) demonstrates, saying: "Stretch your arms out like this. Now close your eyes. Now touch your nose with your right hand, keeping your head still. That's fine. Now touch it with your left hand." S (subject) should touch his nose three times with each hand, alternately.

Scoring criteria. A trial consists of three attempts to touch the nose with the index finger with each hand. The trial is considered passed if each hand touches the nose twice in the three attempts.

Points. + on 1st trial = 3
- on 1st trial = 0

8. Finger Movement

Equipment. None.

Number of trials. Three (if necessary).

Directions. At a given signal S is to place the fleshy part of the left index finger on the fleshy part of the right thumb. S then describes an arc with the right index finger extended, so that it comes into contact with the

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Reprinted from The Lincoln-Oseretsky Motor Development Scale by William Sloan, by permission of the C.H. Stoelting Company, Chicago, Illinois. Copyrighted 1954.

left thumb. Next, S separates the right thumb from the left index finger and rotating in the opposite direction from that of the right index finger, again places the right thumb in contact with the left index finger. E should demonstrate and make sure S makes the arcs in proper fashion. Say, "Do this until I say 'eyes closed', then continue doing it with your eyes closed until I say 'stop.'" S makes arcs with eyes open for 10 seconds and at the signal from E continues making the arcs with eyes closed for 10 more seconds.

Scoring criteria. Both 10-second interval performances are scored. Ten arcs with eyes open within 10 seconds and 10 arcs with eyes closed within 10 seconds constitutes one trial. The movements must be made without confusing the fingers. If one of the three trials is performed correctly the test is passed.

Points. + on any one of 3 trials = 3
- on all three trials = 0

14. Winding Thread

Equipment. A spool of thread.

Number of trials. One trial with each hand.

Directions. The thread should be allowed to unwind to a distance of six and one-half feet and should be fastened securely on one end of the spool. The thread should be unwound when given to S. S should take the thread between the thumb and index finger of the preferred hand and the spool in the other hand. Say: "Let's see how fast you can wind this thread on to the spool. Ready, go!" S should be cautioned against excessively moving the hand holding the spool. After the trial with the preferred hand, the task is repeated with the other hand. Say, "Now we do the same thing with the other hand."

Scoring criteria. E notes the exact time S takes to wind the thread. The maximum time limit for a trial is 30 seconds. The test is passed for a hand if the thread is completely wound on the spool within the time limits given below.

Points. Each hand is scored separately as follows:

Right Hand

Male		Female	
0 to 11 seconds	= 3	0 to 11 seconds	= 3
12 to 15 seconds	= 2	12 to 14 seconds	= 2
16 to 19 seconds	= 1	15 to 20 seconds	= 1
20 or more seconds	= 0	21 or more seconds	= 0

Left Hand

Male		Female	
0 to 13 seconds	= 3	0 to 14 seconds	= 3
14 to 17 seconds	= 2	15 to 20 seconds	= 2
18 to 21 seconds	= 1	21 to 26 seconds	= 1
22 or more seconds	= 0	27 or more seconds	= 0

16. Describing Circles in the Air

Equipment. None.

Number of trials. One.

Directions. S should be seated with both arms extended horizontally at the sides and the hands clenched except for the index fingers which are extended. S describes circles with both index fingers simultaneously. Say: "Let's sit down and stretch your hands out like this. Now don't move your arm or wrist but make nice circles in the air with both your fingers like this." (E demonstrates).

Scoring criteria. Movement must be executed by the fingers only, the rest of the arm should remain essentially motionless. The circles should be easily recognized and should be of approximately the same diameter. Both fingers should work in unison and the movement must be continued for 10 seconds. If S's performance does not meet these criteria the test is failed.

Points. + on 1st trial = 3
- on 1st trial = 0

18. Coins and Matchsticks

Equipment. Two boxes, 20 matchsticks, 20 pennies.

Number of trials. One.

Directions. The two wooden boxes are placed two inches apart on the table in front of the subject within easy reach of each arm. To the subject's right of the right hand box, 20 matchsticks are placed in a heap, to the left of the left hand box, the 20 pennies are placed in a heap. S is to place the matches in the right hand box and the pennies in the left hand box using both hands simultaneously. The matches and pennies must be placed, not thrown into the box. Say: "I want to see how quickly you can do this stunt. When I say 'Go' you are to take coins in your left hand, one at a time, and put them into the box on your left. At the same time, you are to take matchsticks, one at a time, with your right hand and place them in the box on your right. You must do both things at the same time. Do you understand?" (E demonstrates, placing two or three coins and sticks into the boxes simultaneously, and then returning these pieces to the piles before beginning the test.) "Ready, go." E records time to complete the task.

Scoring criteria. The score depends upon the time to complete the task. If S does not place the pieces into the boxes simultaneously, if he throws the pieces into the boxes, or if he picks up more than one piece at a time, he is to be corrected verbally by E.

Points.

Male	Female
0 to 29 seconds= 3	0 to 26 seconds = 3
30 to 39 seconds= 2	27 to 38 seconds = 2
40 to 49 seconds= 1	39 to 50 seconds = 1
50 or more seconds= 0	50 or more seconds = 0

24. Drawing Lines

Equipment. Pencil, a sheet of lined white paper 8 1/2 by 11 inches; the lines should be 3/8 of an inch apart.

Number of trials. Two trials with each hand.

Directions. S should be seated at a table with his forearm resting on the table and holding the pencil as in a writing position. Say: "When I say "Go," I want you to draw as many lines as you can between these two lines (indicate)." E demonstrates, drawing about five perpendicular lines between two of the horizontal lines ruled on the paper. "I want your lines to touch these two lines but not to run over. Do you understand? Ready, go." E records time.

Scoring criteria. Time limit, 15 seconds, right hand; 20 seconds, left hand. The score is the number of lines correctly drawn during the time limit. A line is not counted if it overruns or is short of the horizontal lines on the paper by more than 1/8 of an inch. The distance between the perpendicular lines which S draws is unimportant. Two successive trials are given for each hand. The score for each hand is the mean number of correct lines for the two trials.

Points. Each hand is scored separately as follows:

30 lines and over = 3
20 to 29 lines = 2
10 to 19 lines = 1
0 to 9 lines = 0

36. Balancing a Rod Vertically

Equipment. Wooden rod. (18")

Number of trials. Three trials (if necessary) with each hand.

Directions. S is seated. The hand is closed in a fist with the exception of the extended index finger. S is to balance the rod in a vertical position on the tip of the index finger, for a brief period (see below). He is permitted to use his other hand in the initial balancing. Say: "Let's see if you can balance this rod on your finger like this." (E demonstrates) "Balance the stick until I say stop." If three trials are necessary they are given successively with the same hand. Allow 10 seconds between trials. The test is then repeated with S using his other hand. Allow 10 seconds between trials. The test is then repeated with S using his other hand. Say: "Now let's try to balance the rod with your other hand. Balance it until I say stop. Ready, go!"

Scoring criteria. Rod must be balanced at least 5 seconds with the right index finger and 3 seconds with the left. S is permitted to move arm or body but not to rise from the chair. The test is passed if any one of the three trials is correct.

Points. + on any one trial = 3
- on all three trials = 0

APPENDIX B

PROGRAMMED INSTRUMENTS

POSITIVE AND NEGATIVE
VOLUME IN SCULPTURE

(34)
42

Programmed Learning Text NM[1]

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[1]Pictures 1 through 13 referred to in this text may be found in Appendix B.

POSITIVE AND NEGATIVE
VOLUME IN SCULPTURE

This book is going to help you to learn some things about sculpture.

You will be able to read this instruction book and look at some pictures of objects and sculptures.

The book will tell you step by step what to do. Go as quickly or as slowly as you wish.

TURN TO PAGE 2

A sculpture is an object someone has made. It is not flat like a painting, and it has height, depth, and thickness.

Look at the picture number 13 in the blue book on the table at your left. This shows a sculpture of a cat, but a sculpture doesn't have to be like something else.

The person who makes a sculpture is called a sculptor. He can use many different kinds of material to make his sculpture. Some of these are wood, clay, stone, and metal.

TURN TO PAGE 3

First we need to know what is meant when we talk about volume in sculpture.

In front of you is a book with pictures of objects and sculptures in it. Open it to the first picture.

This is a picture of a doughnut shape made of clay. There are two kinds of volume in the clay doughnut. One is the part that is hard. This is called a solid volume. The other is the part in the middle that is the hole. This is called a void volume. It is given its shape by the solid volume that fills the space that is around it.

TURN TO PAGE 4

Now turn to the second picture. This picture of a tire shows us the same kinds of solid and void shapes as we saw in the picture of the clay doughnut.

Look at it carefully!

Does the void volume of the tire have the same shape as the solid volume?

(36)

44

If you said yes, turn to page 7.

If you said no, turn to page 11.

The center volume is a void volume so we call it negative. Turn to picture number 7. It has a solid part surrounding a void volume. This part is called a positive volume.

The void volume is the hole you can stick your finger through. This part is called a negative volume.

TURN TO PAGE 9.

Right! The piece that looks like an animal ear on the top of the head of the sculptured figure is a solid.

There are some other words which describe solid and void volume. These are positive and negative volume.

Solid volume is one kind of positive volume and void volume is one kind of negative volume.

Look at picture number 6. There are two areas of volume shown in this picture. One is positive and the other is negative.

Is the center volume positive or is it negative?

If you said positive, turn to page 5.

If you said negative, turn to page 8.

The void volume is not exactly the same as the solid volume.

Look at the picture of the clay doughnut. Do you see that the solid volume is round, but has a round hole in the middle of it? The void volume is round too, but it doesn't have a hole in its center.

Solid and void volumes can be many different shapes. Look at the pictures numbered 3 and 4. Some parts of these are solid volume and some are void volume. Look at them carefully and decide which parts are solid and which are void.

TURN TO PAGE 12.

You called the center volume "negative" and you are right!

It is a void negative volume.

TURN TO PAGE 9.

Now you are ready to learn about concave and convex volume.

Look at the picture that is numbered 8. There are two kinds of volumes shown in the picture. They have been made by cutting a ball in half. One of the halves curves inward and partly surrounds space. We call this a concave volume.

The other half curves outward and pushes into space. We call this a convex volume.

TURN TO PAGE 10.

There are concave and convex volumes in many things that we use every day.

Turn to picture number 9. This shows a piece of garden hose that has been cut in half. We can see that the inside part curves around a space. We call this a <u>concave</u> volume.

The other half curves outward and pushes into a space. We call this a <u>convex</u> volume.

TURN TO PAGE 21.

Very good!

The solid volume is round with a hole in the middle formed by the void volume and the void volume is round but has no hole in it.

Solid and void volumes can be many different shapes. Look at the pictures that are numbered 3 and 4. Some parts of these are solid volume and some are void volume.

Look at them carefully and decide which parts are solid and which are void.

TURN TO PAGE 12.

Now you are ready to look at picture number 5.

This is a picture of a sculpture which was cut and hammered from a flat piece of gold by an artist over six hundred years ago. We call the artist who made this a sculptor and the little figure is a sculpture.

We can see that the sculptor carefully cut out voids and left solids in order to form his sculpture.

Do you notice that the pictures of solid and void shapes at which you just looked were copies from parts of this sculpture? Can you find the parts they match?

TURN TO PAGE 13.

There are many parts of this sculpture that have volumes with similar shapes. Some are solids and some are voids.

Two parts of the sculpture in picture number 5 have been given numbers. Can you select the one that is a solid volume of the sculpture?

If you chose 1, turn to page 14.

If you chose 2, turn to page 6.

The part with the number 1 on it is a void volume. This void area is surrounded by a volid volume which outlines and gives it its shape.

Do you see that the part numbered 2 is a solid part?

(41)

TURN TO PAGE 6.

Right again!

The inside partly surrounds space in order to form concave volume, while the outside pushes into space and forms convex volume.

TURN TO PAGE 16.

A concave volume is called negative and a convex volume is called positive.

Look at picture number 12. This little spoon has negative volume and positive volume. There is an A on one part of it.

Pick which of the following pairs of words describes the A part best.

1. convex and negative
2. convex and positive
3. concave and negative
4. concave and positive

If you chose 1, turn to page 18.

If you chose 2, turn to page 20.

If you chose 3, turn to page 25.

If you chose 4, turn to page 23.

When the inside of the cup partially surrounds space it forms a <u>concave</u> volume. When the outside of the cup pushes into space it forms a <u>convex</u> volume.

Turn to number 8 picture again. What kind of volume does the inside of the ping-pong ball form?

If you said concave, turn to page 15.

If you said convex, turn to page 19.

The A part of the spoon is concave but it cannot be positive volume since it curves inward.

Turn to page 16 and try again.

Turn to picture number 11.

The nut that was once inside this shell formed convex volume because it rounded outward into space.

When we look inside the shell we see a volume which is shaped by the curve of the peanut shell.

It is concave shape.

TURN TO PAGE 16.

The part that has the letter A on it curves inward so it cannot be convex. It is partially enclosed space so it cannot be called a positive volume.

Turn to page 16 and try again.

Picture number 10 shows two little cups. Each one has convex and concave volume.

The inside of the cup forms what kind of volume?

If you said convex, turn to page 17.

If you said concave, turn to page 15.

22

Right!

You have done very well. Tell the instructor you have finished and are ready for the next step.

23

You are partly right. Part A curves inward so it is a concave volume. However, it is space partially enclosed by the curved shape of the spoon so it cannot be positive volume.

Turn to page 16 and try again.

Picture number 13 is a picture of a sculptured cat. It has concave and convex volumes. One part of it has the letter B on it. Which of the following pairs of words describes it best?

1. concave and negative volume
2. convex and positive volume

If you chose 1, turn to page 22.

If you chose 2, turn to page 26.

Right!

The A part of the spoon curves inward and is a concave and negative volume.

Now you are ready to look at a picture of a real sculpture with concave and convex volumes.

TURN TO PAGE 24.

You have finished the test. Tell your instructor that you have turned to page 25 and are ready for the next instructions.

(47)

POSITIVE AND NEGATIVE

VOLUME IN SCULPTURE

Programmed Learning Text M[1]

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[1]Pictures 1 through 13 referred to in this text may be found in Appendix B.

POSITIVE AND NEGATIVE

VOLUME IN SCULPTURE

This book is going to help you to learn some things about sculpture.

You will be able to read the book and to look at and feel some parts of sculptures and some real sculptures. You may handle each part as you learn about it.

The book will tell you step by step what to do. Go as quickly or as slowly as you wish.

TURN TO PAGE 2

A sculpture is an object someone has made. It is not flat like a painting, and it has height, depth, and thickness.

Look at the object on the table at your right. This is a sculpture of a cat, but a sculpture doesn't have to be like something else.

The person who makes a sculpture is called a sculptor. He can use many different kinds of material to make his sculpture. Some of these are wood, clay, stone, and metal.

Turn to page 3

First we need to know what is meant when we talk about volume in sculpture.

In front of you is a round disk that you can turn. It has several objects with numbers beside them. Move the disk first to the object numbered 1.

This is a doughnut shape made of clay. There are two kinds of volume in this sculpture of a doughnut. One is the part that is hard and that you can feel. This is called a solid volume. The other is the part in the middle that is the hole. This is called a void volume. It is given its shape by the solid volume that fills the space that is around it.

TURN TO PAGE 4

Now turn the disk to the piece that is numbered 2.

This little tire has the same kinds of solid volume and void volume as you found in the clay doughnut.

Look at it carefully!

Does the void volume of the tire have the same shape as the solid volume?

(50) 56

If you said yes, turn to page 7.

If you said no, turn to page 11.

The center volume is a void volume so we call it negative. Turn the disk to the clay piece numbered 7. Pick it up. It has a solid part you can feel. This part is called a positive volume.

The void volume is the hole you can stick your finger through. This part is called a negative volume.

TURN TO PAGE 9.

Right! The piece fits the solid part which looks like an animal ear on top of the head of the sculptured figure.

There are some other words which describe solid and void volume. These are positive and negative volume.

Solid volume is one kind of positive volume and void volume is one kind of negative volume.

Pick up the clay piece numbered 6. There are two areas of volume in this piece. One is positive and the other is negative.

Is the center volume positive or negative?

If you said positive, TURN TO PAGE 5.

If you said negative, TURN TO PAGE 8.

The void volume is not exactly the same as the solid volume.

Look at the clay doughnut. Do you see that the solid volume is round, but has a round hole in the middle of it? The void volume is round too, but it doesn't have a different kind of volume in its center.

Solid and void volumes can be many different shapes. Look at the clay pieces on the disk that are numbered 3 and 4.[1] Pick them up and feel the parts that are solid volume and void volume. Look at them and decide which are solid and which are void.

TURN TO PAGE 12.

You called the center volume "negative" and you are right!

It is a void negative volume.

TURN TO PAGE 9.

Now you are ready to learn about concave and convex volume.

Look at the piece on the disk that is numbered 8. There are two kinds of volumes on this piece of cardboard. They have been made by cutting a ball in half. One of the halves curves inward and partly surrounds space. We call this a concave volume.

The other half curves outward and pushes into space. We call this a convex volume.

TURN TO PAGE 10.

There are concave and convex volumes in many things that we use every day.

Turn to number 9 on the disk. This piece of garden hose has been cut in half. Pick it up and feel that the inside part curves around a space. We call this a concave volume.

When you turn it over it curves outward and pushes into space. We call this a convex volume.

TURN TO PAGE 21.

Very good!

The solid volume is round with a hole in the middle formed by the void volume and the void volume is also round but has no hole in it.

Solid and void volumes can be many different shapes. Look at the clay pieces on the disk that are numbered 3 and 4. Pick them up and feel the parts that are solid volume and void volume.

Look at them and decide which are solid and which are void.

TURN TO PAGE 12.

(53) 61

Now you are ready to look at a copy of a sculpture. It is on the table at your left. The original was cut and hammered from a flat piece of gold by an artist over six hundred years ago. We call the artist who made this a sculptor and the little figure is called a sculpture.

We can see that the sculptor carefully cut out voids and left solids in order to form the figure.

Do you notice that the solid and void clay pieces you just saw and felt were copied from parts of this sculpture? Can you find the parts that match?

TURN TO PAGE 13.

There are many parts of this sculpture that have volumes with similar shapes. Some are solids and some are voids.

Turn the disk to number 5. Here you will find two solid shapes that match some volumes of the sculptured figure. Pick them up and try to find the parts of the sculpture that they match.

Which one fits a solid volume of the sculpture?

If you chose 1, TURN TO PAGE 14.
If you chose 2, TURN TO PAGE 6.

The piece with the number 1 on it fits a void volume near the bottom of the little sculpture.

This void area is surrounded by a solid volume which outlines and gives it its shape.

See if you can find the solid volume which shape number 2 fits.

(55)

TURN TO PAGE 6

Right again!

The inside partly surrounds space in order to form concave volume, while the outside pushes into space and forms convex volume.

TURN TO PAGE 16.

A concave volume is called a negative and a convex volume is called a positive.

Pick up number 12 on the disk. This little spoon has negative volume and positive volume. There is an A on one part.

Pick which of the following pairs of words describe the A part best.

1. convex and negative
2. convex and positive
3. concave and negative
4. concave and positive

If you chose 1, TURN TO PAGE 18.

If you chose 2, TURN TO PAGE 20.

If you chose 3, TURN TO PAGE 25.

If you chose 4, TURN TO PAGE 23.

When the inside of the cup partially surrounds space it forms a concave volume. When the outside of the cup pushes into space it forms a convex volume.

Turn to number 8 on the disk again. What kind of volume does the inside of the ping-pong ball form?

If you said concave, turn to page 15.

If you said convex, turn to page 19.

The A part of the spoon is concave but it cannot be positive volume since it curves inward.

Turn to page 16 and try again.

Turn to shape number 11 on the disk. The nut that was once inside this shell formed convex volume because it rounded outward into space.

When we look inside the shell we see a volume which is shaped by the curve of the peanut shell.

It is a concave shape.

TURN TO PAGE 16.

20

The part that has the letter A on it curves inward so it cannot be convex. It is a partially enclosed space so it cannot be called a positive volume.

Turn to page 16 and try again.

21

Number 10 on the disk is two little cups. Each one has convex and concave volume.

The inside of the cup forms what kind of volume?

If you said convex, TURN TO PAGE 17.

If you said concave, TURN TO PAGE 15.

Right!

You have done very well. Tell the instructor you have finished and are ready for the next step.

You are partly right. Part A curves inward so it is a concave volume. However, it is space partially enclosed by the curved shape of the spoon so it cannot be positive volume.

Turn to page 16 and try again.

(59) 67

This sculptured cat has concave and convex volumes. One part of it has the letter B on it. Which of the following pairs of words describe it best?

1. concave and negative volume
2. convex and positive volume

(90) If you chose 1, TURN TO PAGE 22.

If you chose 2, TURN TO PAGE 26.

Right!

The A part of the spoon curves inward and is a concave and negative volume.

Now you are ready to look at a real sculpture with concave and convex volumes.

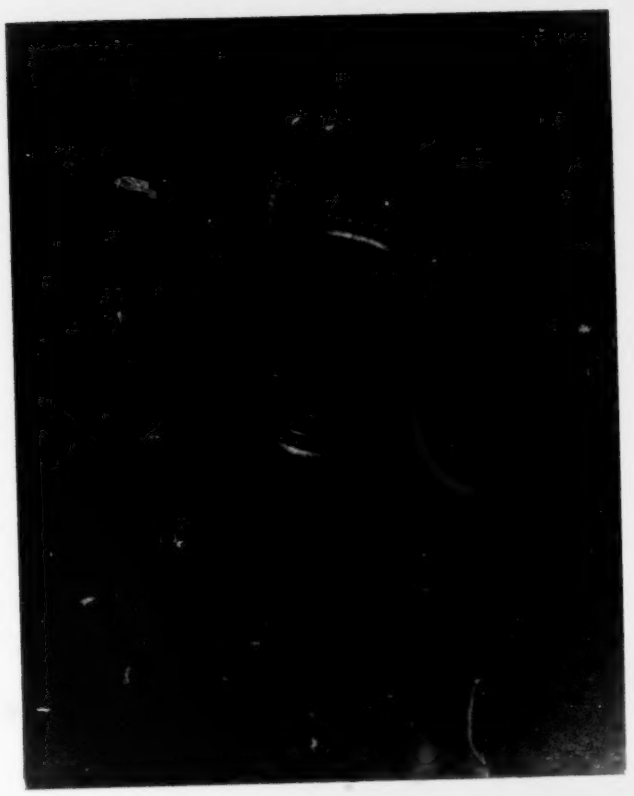
TURN TO PAGE 24.

You have finished the text. Tell your instructor that you have turned to page 25 and are ready for the next instructions.

Figure 6 Clay "Doughnut" Illustrating Soiid and Void Volume.

Picture 1

Figure 7 Tire Showing Solid and Void Volume.

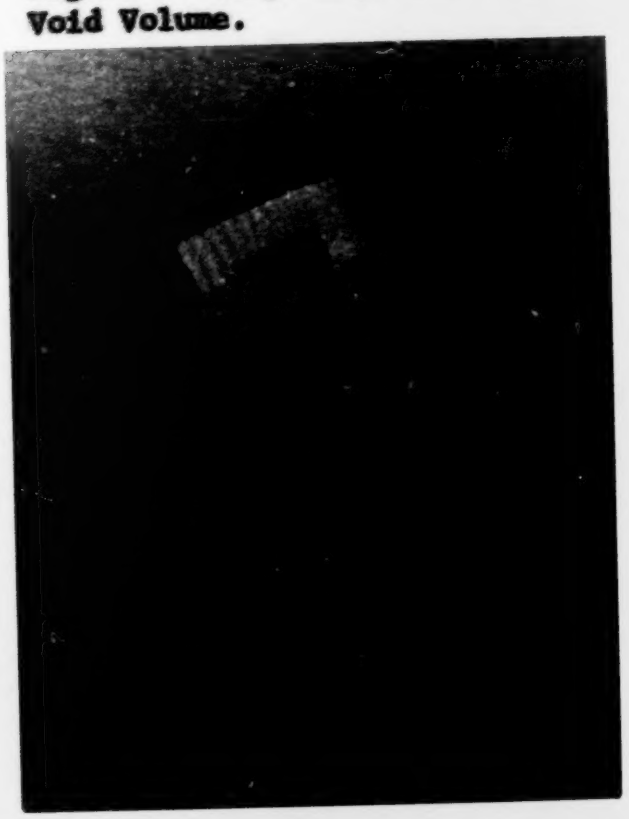


Picture 2

Figure 8 Clay Square Showing Void Volumes.

Picture 3

Figure 9 Clay Shape Showing Void Volume.



Picture 4

Figure 10 Ceremonial Columbian Knife

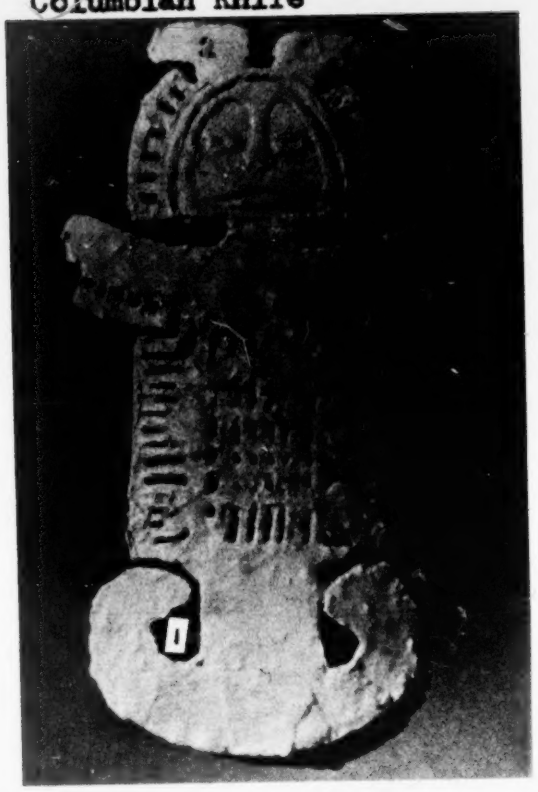
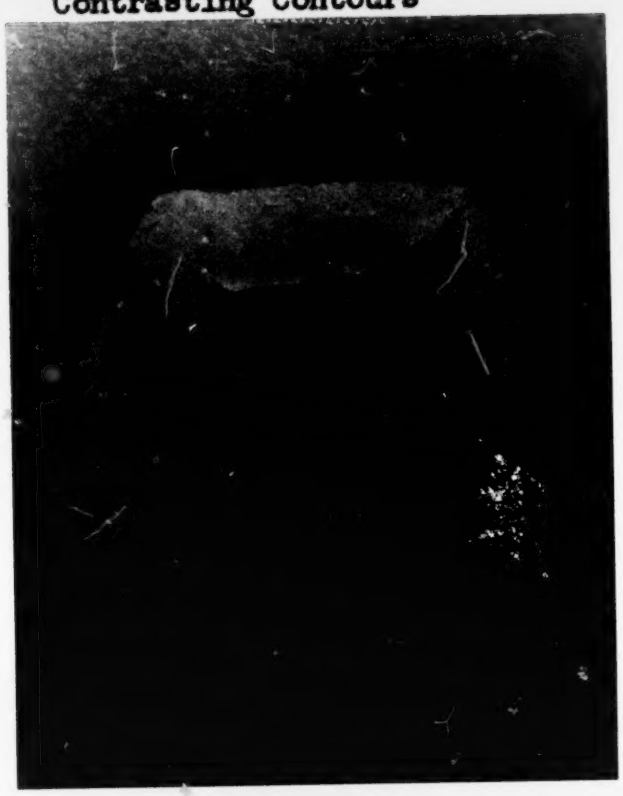


Figure 4 Clay Shape with Contrasting Contours

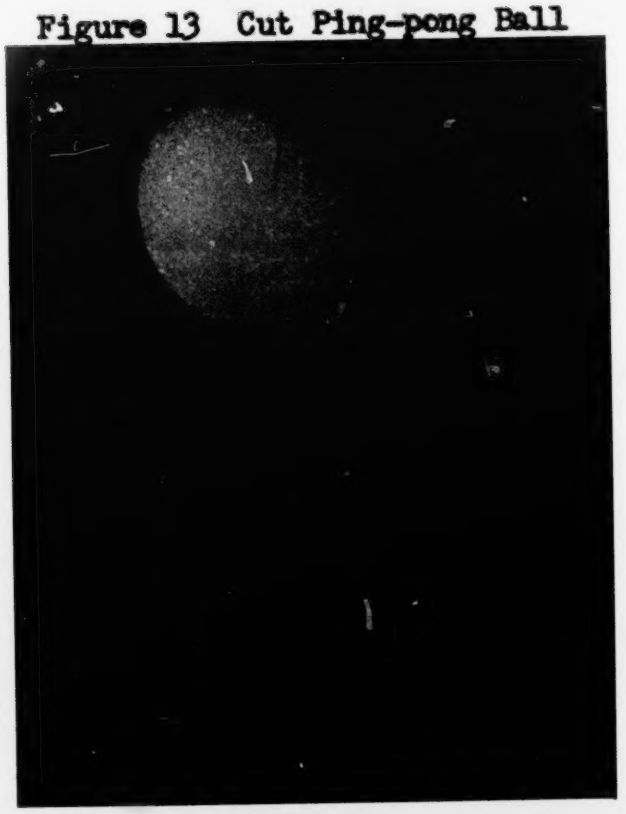


PICTURE 6

Figure 12 Textured Clay Object

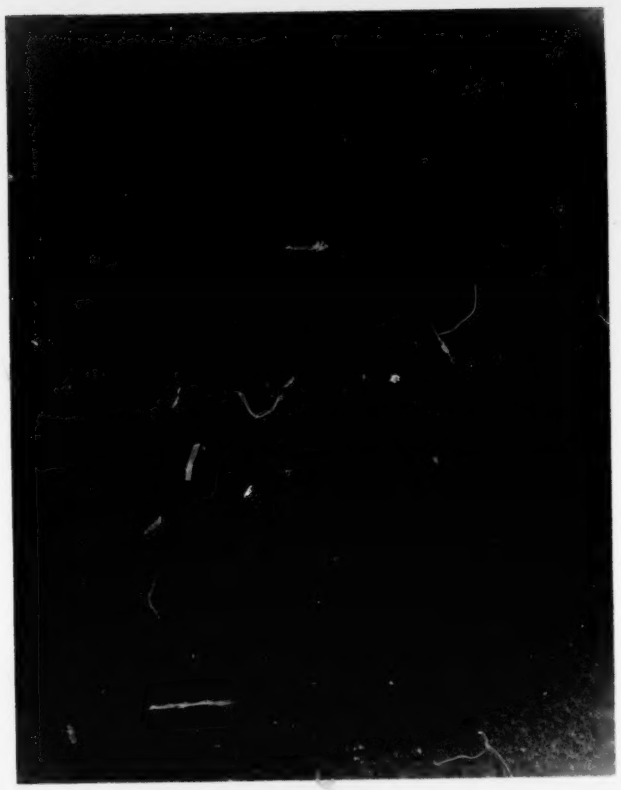
PICTURE 7

Figure 13 Cut Ping-pong Ball



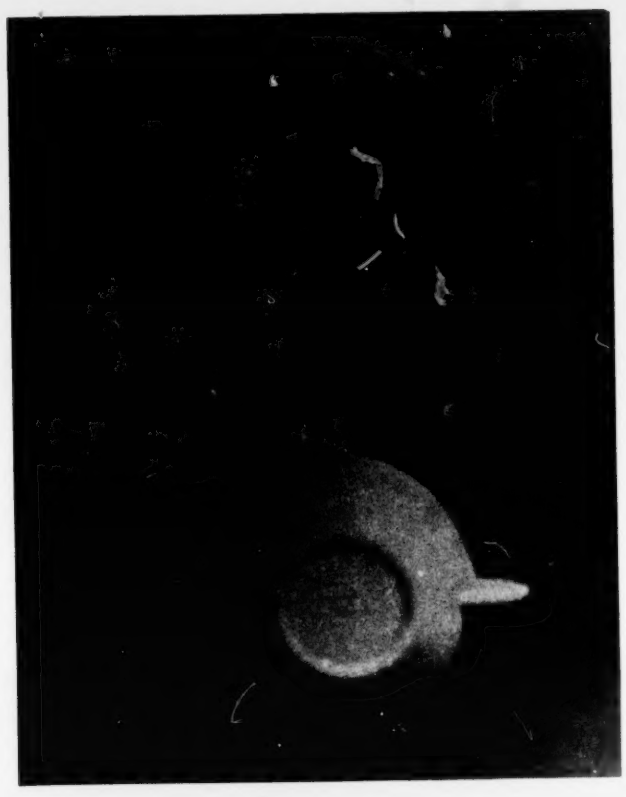
PICTURE 8

Figure 14 Cut Hose



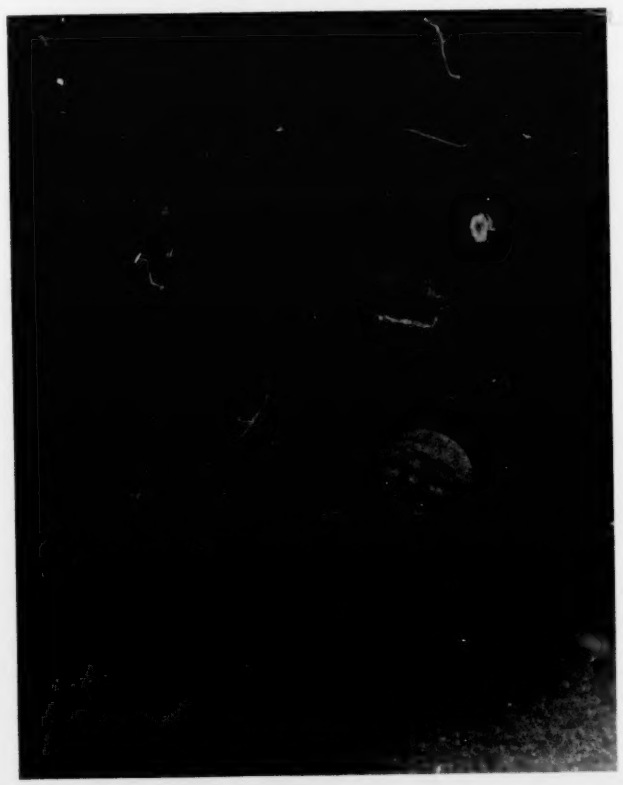
PICTURE 9

Figure 15 Two Views of Cup



PICTURE 10

Figure 16 Peanut Shells

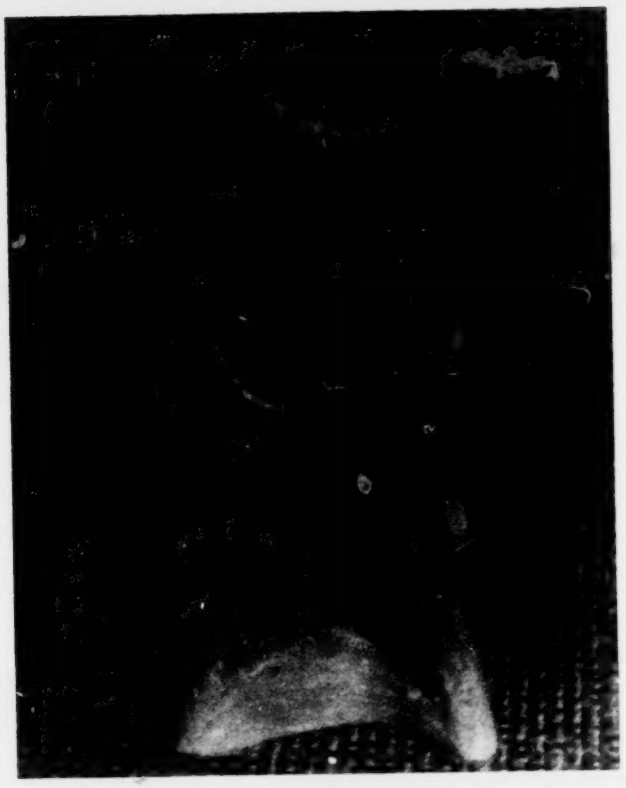


PICTURE 11

Figure 17 Spoon with Concave Volume A.

PICTURE 12

Figure 18 Sculptured Cat.



PICTURE 13

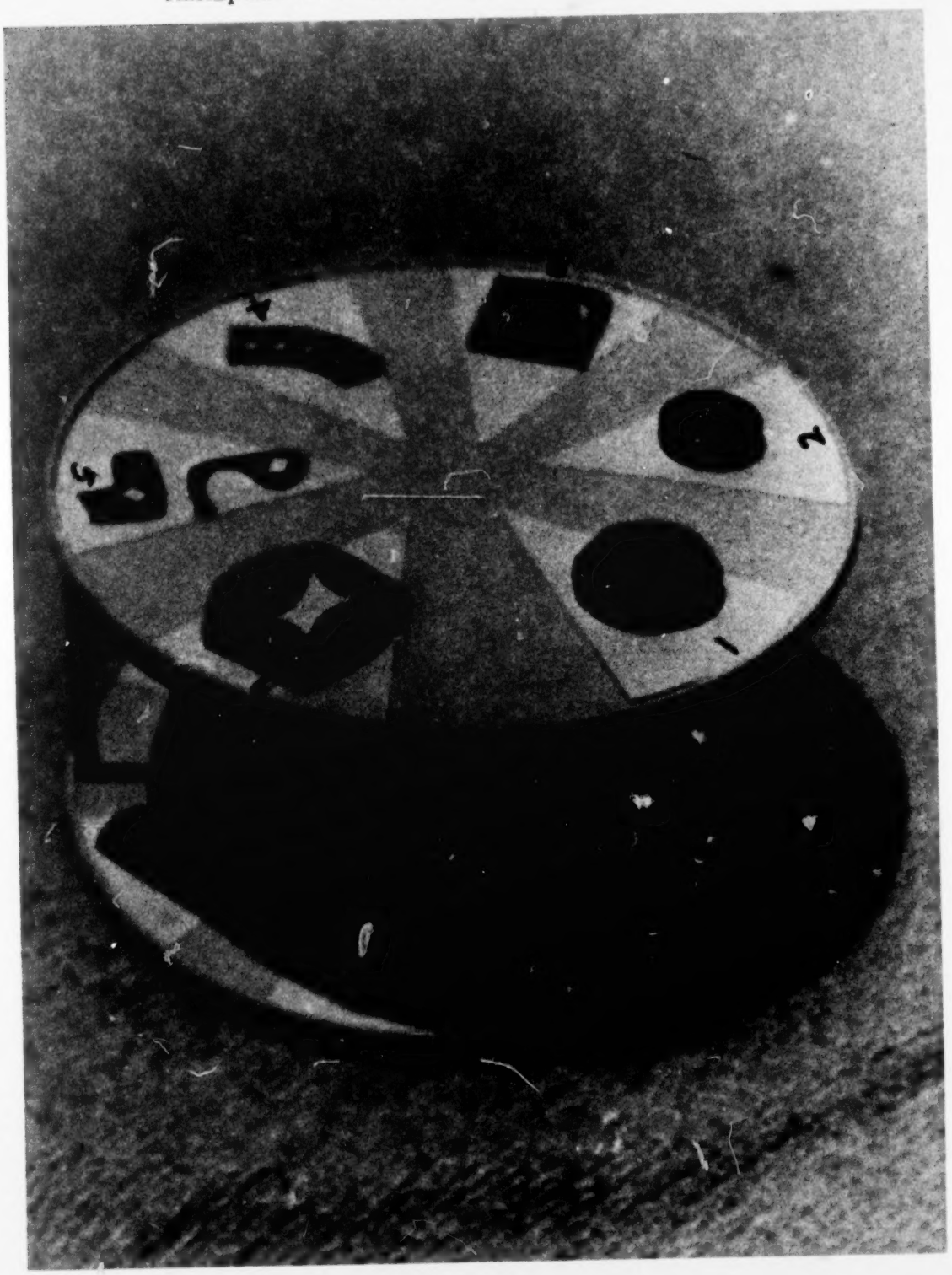
MANIPULATIVE INSTRUMENT

A turntable disk[1] having two shelves was used to display the objects pictured in Figures 6 through 9 and 11 through 17. The objects were placed on numbered spaces and were available to the student to look at, pick up, and feel as he was instructed during the manipulative instrument. The sculpture pictured in Figures 10 and 18, which were shown to the subjects taking the non-manipulative instrument through photographs only, were placed beside the disk and were available for handling by those subjects being given the manipulative instrument.

---

[1] Figure 19

Figure 19 Turntable Disk used with the - Manipulative Instrument



APPENDIX C

ACHIEVEMENT TESTS

LEARNING ACHIEVEMENT TEST
(P.P.A.T. 1 and 2)

There are four sculptures on the table in front of you. Each one has a number and each one has two letters fastened to certain parts. Tell what kinds of positive or negative volume each part is by filling in the blanks in the following sentences.

1. The letter A on sculpture number one is on a _____ positive volume.

2. The part of sculpture number two with the letter B on it is a _____ positive volume.

3. The letter C is beside a hole in sculpture number three. This part is called a _____ negative volume.

4. Part D of sculpture number four is in an area that is a _____ negative volume.

5. The letter E is on sculpture number one. It is on a part that is a _____ positive volume.

6. The letter F is beside the part of sculpture number two that represents the eye. That eye area is called a _____ negative volume.

7. Sculpture number three has the letter G on a part that is at the top. This is a _____ positive volume.

8. Part H of sculpture number four is a _____ negative volume.

Answers: 1. convex, 2. solid, 3. void, 4. void, 5. solid, 6. concave, 7. convex, 8. concave.

Spelling errors were referred to judges for decisions as to whether or not they were acceptable approximations of the above answers.

SCULPTURE USED FOR P.P.A.T.
ACHIEVEMENT TESTS

Figure 20 Grave Doll. A indicates Convex Volume. E indicates Solid Volume.

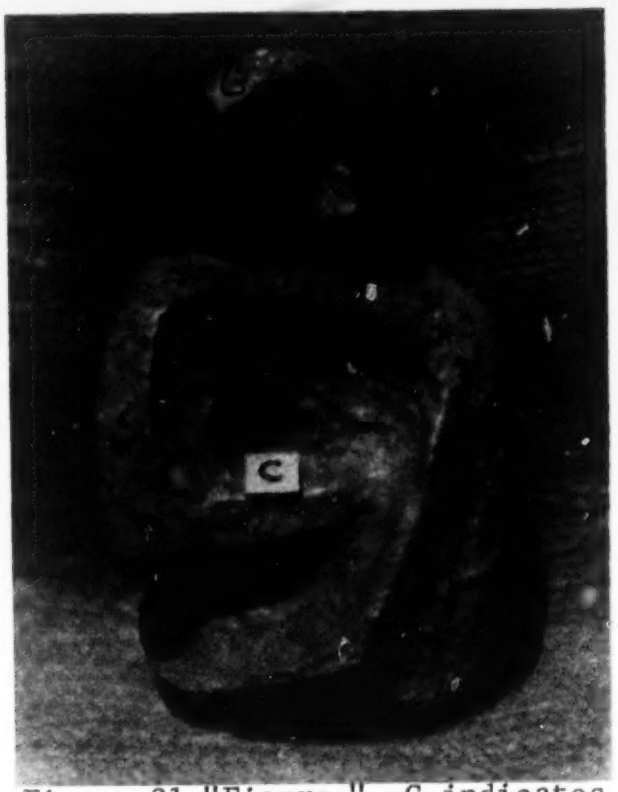


Figure 21 "Figure." C indicates Void Volume. G indicates Convex Volume.

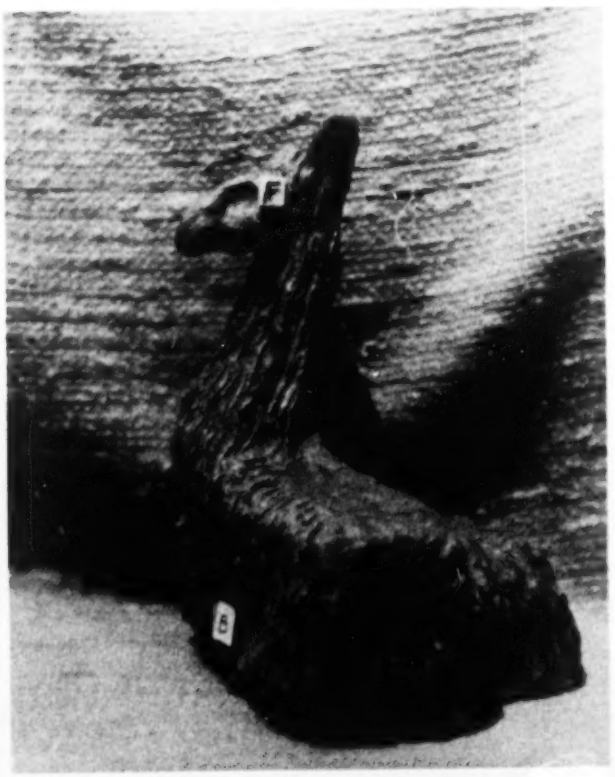


Figure 22 Llamas. B indicates Solid Volume. F indicates a Concave Volume.

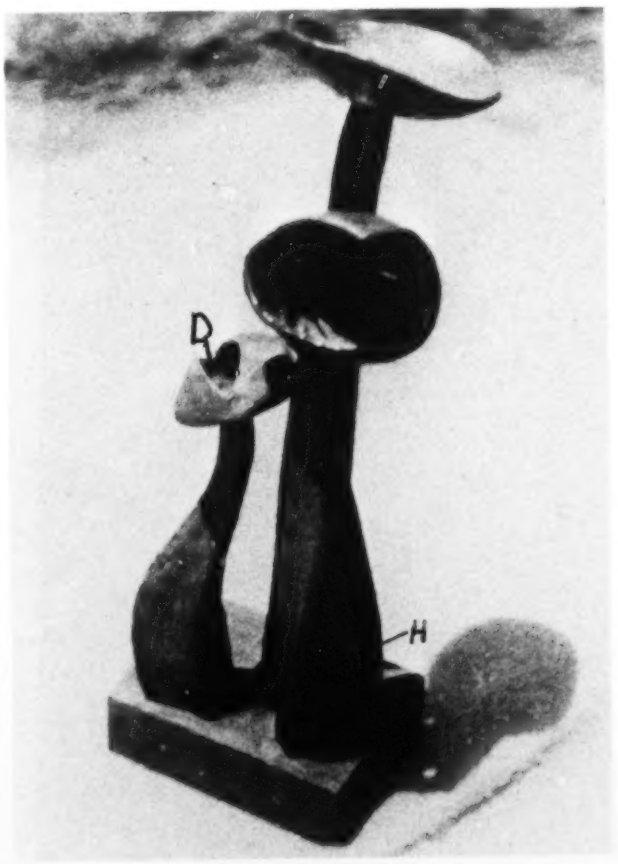


Figure 23 Fungi. H indicates Concave Volume. D indicates Void Volume.

Paper-and-Pencil Achievement Test

The subject was directed to specific parts of the four sculptures for examples of each of the concepts. Each of the four positive or negative examples was indicated two times, once in a more subtle occurrence. Although number of correct answers was the criterion for measurement, the incidence of the concepts in less obvious form allowed for a finer test of knowledge by the subject. The subject was able to view these sculptured pieces at close range and to walk around them, pick them up, or feel them if he wished. Three of the sculptures were made for use in the Florida study and one was a Nicaraguan "grave doll." Each sculpture presented two different concepts for test purposes.

Instructions to the subjects were as follows:

> The four pieces of sculpture on the table in front of you are described in the sentences on this sheet of paper. Put your name at the top, then follow the instructions on the paper. You are to fill in the blanks with what you feel is the best answer. If there are answers you don't know, you may guess or leave them blank. You may use twenty minutes to fill these blanks. When you are through bring the sheet of paper to me.

Clay Object Achievement Test

The second Achievement Test was devised as a manipulative demonstration of the subject's knowledge of the concepts. He was given one-half pound of clay and asked to make use of the clay to show what he knew about positives and negatives in sculpture.

Instructions to the subjects were as follows:

> Take this piece of clay and use it to show me what you know about all the different kinds of positive and negative volume in sculpture. You may have twenty minutes in which to work. When you are through bring your clay to me and tell me about it.

It was felt that this part of the test offered the subject a less verbal means of demonstrating what he knew, and that emphasis thus being placed on manual manipulation might provide a preferred means of demonstrating knowledge for subjects with higher motor PRs than verbal PRs. When the student's clay was brought to the examiner, the subject was asked to point to and tell about any positive or negative volumes which he had used as follows:

> Put your clay on the table and let's look at it. Can you point to any place where you have used one of the kinds of positive or negative volume? Can you tell me what the name of that kind of positive or negative volume is? Do you see any more?

As the subject talked about his sculpture and pointed out parts, the examiner made a sketch of the object. The parts to which the subject was pointing were indicated on the drawing as well as notations of his use of any of the four terms required for correct answers.

The words "concave, convex, solid, and void" were accepted as correct answers in both tests. Scoring for each test was from 0 to 8 points with one point for each correctly used instance of the four words called for in the eight item P.P.A.T. In the C.O.A.T. two references to one kind of positive or negative volume were counted if they referred to different instances within the sculpture.